Makoshika State Park
Road Infrastructure Repairs
Glendive, Montana

Contract Documents, Specifications & Drawings
RPA Project No. 17353
June 2018

Prepared by _____
Robert Morton, P.E., Project Manager

Checked by _____
Brad Thompson, P.E., Project Manager

QA/QC Approval _____
Jeff Key, P.E., Operations Manager

Date Approved JUNE 7, 2018

ROBERT PECCIA & ASSOCIATES

HELENA
P.O. Box 5653
3147 Saddle Drive
Helena, MT 59601
(406) 447-5000
(406) 449-5036 FAX

SPECIAL PROVISIONS

CONTENTS

1. PROJECT DESCRIPTION

The project generally includes the repair and reconstruction of Makoshika State Park Road. The design calls for full depth reclamation with cement treated base (FDR w/ CTB) of about 2.5 miles of road; associated drainage and culvert repairs; and related utility work. The project includes a Base Bid and one Additive Alternate, generally described as follows:

Base Bid: The base bid work incudes road reconstruction work from Station 64+00 to 132+73, or about 1.3 miles. The FDR w/ CTB work includes typical and thickened sections for different soil conditions. Other work for this section of roadway includes delineator removal and replacements, sign replacement, and utility crossings. Work also includes culvert and drainage repairs, riprap placement, and disturbed area revegetation throughout the whole project, from the park boundary at Station 0+00 to station 132+73.

Additive Alternate #1: This work includes the FDR w/ CTB road work from Station 34+12 to 64+00, or about 0.6 miles. The FDR w/ CTB work includes typical and thickened sections for different soil conditions. Additional work includes delineator replacement, sign replacement and utility crossings for the same section of roadway.

2. SITE INSPECTION AND PREBID CONFERENCE

All Bidders should satisfy themselves as to the construction conditions by personal examination of the site of the proposed work and any other examination and investigation that they may desire to make as to the nature of the construction and the difficulties to be encountered.

A prebid conference will be held on site. See Invitation To Bid in these Contract Documents for time and location. Those interested in bidding the project are encouraged to attend this meeting.

3. PROJECT RELATED CONTACTS

Wherever in these Documents the word "Owner" appears, it shall be understood to mean:

Owner: Montana Fish, Wildlife & Parks
Design and Construction Unit
1522 9th Avenue, PO Box 200701
Helena, MT 59620-0701
Contact: Darcy Yakoweshen
Telephone: (406) 841-4019

Wherever in these Documents the word "Engineer" appears, it shall be understood to mean Robert Peccia & Associates, Inc. The firm of Robert Peccia & Associates, Inc. has been duly authorized by the Owner as the Engineer for the engineering design, submittal review, and construction observation and will serve as the "Engineer" for those functions as related to this project.

Engineer: Robert Peccia & Associates (RPA)
3147 Saddle Drive, P.O. Box 5653
Helena, MT 59601
Contact Person: Robert Morton, P.E.
Telephone: (406) 447-5000

4. ADDITIONAL INSUREDS

In accordance with the insurance requirements outlined in the General Conditions, the following entities shall be included as additional insureds:

OWNER:
Montana Department of Fish, Wildlife & Parks
ENGINEER:
Robert Peccia & Associates, Helena, MT

Use the Additional Insured Endorsement CG 20 32 or equivalent, acceptable to the Owner and Engineer.

5. SAFETY STANDARDS

The Contractor shall be solely and completely responsible for conditions of the jobsite, including safety of all persons (including employees) and property during performance of the work. This requirement shall apply continuously and not be limited to normal working hours. Safety provisions shall conform to U.S. Department of Labor (OSHA), and all other applicable federal, state, county, and local laws, ordinances, codes, and regulations. Where any of these are in conflict, the more stringent requirement shall be followed. The Contractor's failure to thoroughly familiarize himself with the aforementioned safety provisions shall not relieve him from compliance with the obligations and penalties set forth therein.

The Contractor shall develop and maintain for the duration of this contract a safety program that will effectively incorporate and implement all required safety provisions. The Contractor shall appoint an employee who is qualified and authorized to supervise and enforce compliance with the safety program.

The duty of the Engineer to conduct construction review of the work does not include review or approval of the adequacy of the Contractor's safety program, safety supervisor, or any safety measures taken in, on, or near the construction site.

The Contractor, as a part of his safety program, shall maintain at his office or other well-known place at the jobsites, safety equipment applicable to the work as prescribed by the aforementioned authorities, all articles necessary for giving first-aid to the injured, and shall establish the procedure for the immediate removal to a hospital or a doctor's care of persons (including employees) who may be injured on the jobsite.

If death or serious injuries or serious damages are caused, the accident shall be reported immediately by telephone or messenger to both the Owner and the Engineer. In addition, the Contractor must promptly report in writing to the Owner and the Engineer all accidents whatsoever arising out of, or in connection with, the performance of the work whether on, or adjacent to, the site, giving full details and statements of witnesses.

If a claim is made by anyone against the Contractor or any Subcontractor on account of any accident, the Contractor shall promptly report the facts in writing to the Owner and the Engineer, giving full details of the claim.

The Contractor shall take all necessary provisions for safe handling of chemical amendments and potentially hazardous wastes, including apprising himself of hazards, developing safety plans, providing emergency and decontamination services, and developing spill containment procedures.

6. GENERAL CONSTRUCTION REQUIREMENTS

A. Quality Assurance. The Engineer will monitor the construction of work covered by this section to determine if the work is being performed in accordance with the contract requirements. The Engineer does not have the authority or the means to control the Contractor's methods of construction. It is, therefore, the Contractor's responsibility to utilize all methods, equipment, manpower, and other means necessary to assure that the work is installed in compliance with the Drawings and Specifications, and laws and regulations applicable to the work. All buried work items shall be installed in the presence of the Engineer or may not be considered for payment.

B. Grade and Alignment. The Engineer will provide benchmark elevations throughout the entire project area as necessary. The Contractor shall provide, with his own equipment, tools, material, and labor, all intermediate line and grade control necessary to install the work within the tolerances specified. The Contractor shall calibrate and maintain all line and grade control equipment, including transits, levels, lasers, and other equipment, periodically to assure their accuracy.

C. Tolerances. Construction tolerances for the work, shall be as outlined in the Technical Specifications.

D. Construction Limits. Where construction limits, or property lines, are not specifically called out on the Drawings, the limit shall be 20 feet, when measured from the centerline of the new pipe, or to the adjacent property line, whichever is less. Disturbance and equipment access beyond this limit is not allowed without the written approval of both the Engineer and the owner of the affected property. If so approved, disturbance beyond construction limits shall meet all requirements imposed by the landowner; this includes existing roads used and/or improved as well as the construction of new access roads. Special construction, reclamation, or post-construction road ripping or other closure provisions required by the

landowner on access roads beyond the construction limits shall be performed by the Contractor at no additional cost to the Owner.

E. Areas of Disturbances. Approved areas of disturbance are those areas disturbed by construction activities within the construction limits and along designated or approved access routes. Such areas shall require reclamation and revegetation operations, including grading to the original contours, topsoiling with salvaged or imported topsoil, seeding, fertilizing, and mulching as specified herein.

Other areas that are disturbed by the Contractor's activities outside of the limits noted above will be considered as site damage or unapproved areas of disturbance subject to the repair and replacement quality as specified herein. Such areas will also require the reclamation and revegetation operations noted above and as specified herein, but costs of such work shall be borne by the Contractor. This includes areas selected by the Contractor outside the defined construction limits for mobilization, offices, equipment, or material storage.

The Contractor shall order sufficient materials to perform the required work for all areas of disturbance. The Contractor will pay for the required revegetation work in all unapproved areas of disturbance.

F. Technical Specifications. These Special Provisions augment the Technical Specifications that are referenced and provided in later sections of this document. Specifically Technical Specifications apply to this project from the following sources:

1. Montana Public Works Standard Specifications (MPWSS),
2. Montana Department of Transportation Standard Specifications for Road and Bridge Construction (MDTSS)
3. Federal Highway Administration, Federal Lands Highway, Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects (FHWA FP-14)

7. ENGINEERING INTERPRETATIONS

A. Engineering Decisions: It is realized that timely engineering decisions on construction activities or results have an important bearing on the Contractor's schedule. On this project the Engineer will make every effort to have a Resident Project Representative (RPR) readily available to the project when needed during the construction period, who has the authority to make judgment calls on matters dealing with interpretation of the plans and specifications, with the one qualification; that he shall have the right to take twenty-four (24) hours to confer with other Engineers before giving said decision.

1. Engineer availability may be by phone and may not be on site for the full construction period.

B. When the decision affects a plan design or specification change, it should be realized that more time may be required than twenty-four (24) hours to gain the

necessary Owner and funding source participation in the decision process including time for formal change order preparation as required.

8. DISPUTES

A. Scope. This section covers the procedures to be followed in the event any part of the work or any change thereto becomes disputed and agreement between the Contractor and the Owner cannot be reached. Arbitration of unresolved disputes is discussed in the General Conditions.

B. Notification. The Contractor shall give written notice to the Engineer indicating that he is not in agreement with certain aspects of the work. The Engineer may give the Contractor a written directive to proceed with the disputed work and to maintain complete and accurate records of the time and costs associated therewith.

C. Maintenance of Progress. Time is of the essence in completion of this project. The Contractor shall continue to actively execute all work that is not directly affected by the disputed work. When the Engineer gives the Contractor a written notice to proceed with the disputed work, the Contractor shall, without delay, issue a notice of protest and intent to claim and proceed with the disputed work. Failure of the Contractor to actively and effectively pursue the work shall be sufficient grounds for the Owner to terminate the services of the Contractor as provided in the General Conditions except, however, that a 10-day notice of termination shall be given only once. Resumption of work by the contractor, after receiving notice of termination, will not reinstate the 10-day notice period; and the Owner may at any time after the 10-day period immediately take whatever action the Owner deems necessary to maintain the construction schedule, at the Contractor's expense.

9. ENGINEERING, INSPECTIONS, AND TESTING

Test and inspect all work as necessary to insure compliance with the Contract Documents. Complete payment will not be made until the Contractor has demonstrated that the work is complete and will perform as required. See Section 01400 – Quality Control and Quality Assurance for the specific sitework material testing and quality control requirements. Address failed testing until passing by the Contractors independent source.

10. CONSTRUCTION SURVEYS BY CONTRACTOR

A. Northings, eastings and elevations are available from the Engineer in an ACAD or ASCII electronic format for the established control points and subsequent design features. The Contractor shall provide all construction staking, slope staking and blue tops as required in the course of the work.

1. **ELECTRONIC TRANSFER OF DOCUMENTS.** Any information contained in the electronic files being transmitted herewith is for informational purposes only. Recipient acknowledges that the information contained herein may either be in draft form or may be revised at any time. Accordingly, Robert Peccia & Associates (RPA) makes no representations as to the accuracy of this information. Any conclusion or information obtained or derived from these electronic files will be at the user's sole risk.

2. Copies of documents that may be relied upon are limited to the printed copies also known as hard copies that are signed and sealed by the Engineer. Files in electronic media format of text, data, graphics, or of other types that are furnished by the Engineer to the Owner or others, are only for the convenience of the recipient.

3. All information contained on these electronic files was prepared by RPA as instruments of service and are the property of RPA, which expressly reserves all ownership rights including any common law, statutory or copyrights. This electronic data is intended for use on this project only and shall not be used or relied upon in part or in whole for any future work on the same project site, or any other project. The recipient of this information shall not copy, use or modify this information without the prior written authorization of RPA.

4. The drawings and/or data contained herein conform to RPA's standard format. RPA will consider any request for providing the electronic data in another format, but such request may be considered to be a change in services.

5. When transferring documents in electronic media format, Engineer makes no representation as to long term compatibility, usability, or readability of documents resulting from the use of software application packages, operating systems, or computer hardware differing from those used by Engineer at the beginning of this project.

6. The recipient agrees, to the fullest extent permitted by law, to defend, indemnify, and hold RPA harmless from and against any claim, liability or cost (including attorney's fees and defense costs, whether or not a suit is filed) arising out of any unauthorized use, reuse or modification of this information, or in any way connected with the incompatibility, readability, or durability of the information contained herein by the recipient or any person or entity that acquires or obtains this information thereon from the recipient without written authorization from RPA.

B. Layout Surveys. The construction plans show key proposed elevations and any design survey control points obtained by the Engineer which are considered suitable for construction layout. Additional control points and bench marks needed to layout the project shall be established by the Contractor for control of

the work and reference by the Engineer. Additional control points and benchmarks established by the contractor may not be based on the key proposed elevations. The Contractor shall lay out the work by establishing all lines and grades at the site necessary to construct the work and shall be responsible for all measurements that may be required for the execution of the work to the location and limit marks prescribed in the Specifications or on the Contract Drawings.

C. The Contractor shall provide an independent survey crew to provide survey control. Construction staking may be performed by the Contractors personnel, but subsequent surveys to determine final elevations shall be performed by the original independent survey crew. Checks for conformance with grades required by contract plans and specifications will be performed at appropriate intervals to ensure that grading is to the planned elevations.

D. All notes shall be reduced and in a form acceptable to the Engineer (i.e. N,E,Z,D ASCII or ACAD format or similar approved format.)

E. If control points and/or bench marks are disturbed during the course of construction, replacement of all horizontal and vertical control shall be made by the Contractor at no additional cost to the Owner.

F. The Contractor shall be responsible for verification of all existing pavement elevations where new pavement will abut existing pavement. The Contractor shall notify the Engineer of any discrepancies between plan elevations and verified field elevations or dimensions.

G. The Owner may require that work be suspended at any time when control points established at the site by the Contractor are not reasonably adequate to permit checking of the work.

H. The Contractor shall establish and maintain, at the site of the work, as a minimum requisite, the following horizontal and grade control:

1. Preliminary grade stakes and slope stakes.
2. Finished blue-top grade stakes not to exceed a distance of 50-feet longitudinally and 10-feet transversely and steel pins appropriately identified and protected for control points or benchmarks. This blue top requisite is a minimum required and in no case, shall it supersede more stringent blue top requirements specified elsewhere in these project specifications, contract documents, or the MPWSS.

I. For surveys necessary to determine the amount of progress payments, the Contractor will be required to furnish all personnel, equipment and material required to make such surveys as are necessary to determine the quantities of work performed or placed during the period covered by the progress payment.

J. Original field notes, computations and other records taken by the Contractor for the purpose of quantity and progress surveys shall be furnished promptly to the Engineer and shall be used to the extent necessary in determining the proper amount of payment due to the Contractor.

K. These field notes, computations and other records shall be neat and orderly. Field notes shall be complete and in a standard format approved by the Engineer. Unless waived in each specific case, all quantity surveys made by the Contractor shall be made under the direct supervision of the Engineer.

11. UTILITIES

The exact locations of existing underground utilities that may conflict with the work are not precisely known. It shall be the Contractor's responsibility to contact the owners of the respective utilities and arrange for field location services.

A. Notification. The Contractor shall contact, in writing, all public and private utility companies that may have utilities that may be encountered during excavation. The notification shall include the following information:

1. The nature of the work that the Contractor will be performing.
2. The time, date and location that the Contractor will be performing work that may conflict with the utility.
3. The nature of work that the utility will be required to perform such as moving a power pole, supporting a pole or underground cable, etc.
4. Requests for field location and identification of utilities.

A copy of the letter of notification shall be provided to the Engineer. During the course of construction, the Contractor shall keep the utility companies notified of any change in schedule or nature of work that differs from the original notification.

B. Identification. All utilities that may conflict with the work shall be the Contractor's responsibility to locate before any excavation is performed. Field markings provided by the utilities shall be preserved by the Contractor until actual excavation commences. All utility locations on the Drawings should be considered approximate and should be verified in the field by the Contractor. The Contractor shall also be responsible for locating all utilities that are not located on the Drawings.

1. Utility depths from past “As-Built” Record Drawings are available from the Engineer and should be considered approximate and require field verification. Record utility depth and locations for incorporation into this projects’ “As-Built” Record Drawings.
2. Phone lines typically run parallel to buried power lines throughout the project. Field verify location and depth.
3. Geofabric was used in parts of past road designs and shall be anticipated in the planned work.

C. Removal or Relocation of Utilities. This section applies to all utilities including electric power, gas, telephone and television utilities. Whenever there is a direct conflict between the work being performed and the utility, the Contractor shall be responsible to coordinate with the utility company and to remove, relocate or temporarily support the utility during the course of construction. Any charges by the utility for removing, relocation or temporarily supporting the utility shall be paid for by the Contractor.

1. Provide a power connection to the buried power at the Gunners Ridge Trailhead for future Park use. Provide a lockable waterproof junction box with secure and protected cabling.

D. Public Utilities. Water, sewer, storm drainage, street lighting and other utilities owned and operated by the public entities shall, unless otherwise specifically requested by the utility owner, be removed, relocated, supported or adjusted as required by the Contractor at the Contractor's expense. All such work shall be in accordance with these Specifications, or the Owner's Standard Specifications or written instructions when the work involved is not covered by these Specifications.

E. Other Utilities. Utilities owned and operated by private individuals, railroads, school districts, associations, or other entities not covered in these Special Provisions shall, unless otherwise specifically requested by the utility owner, be removed, relocated, supported or adjusted as required by the Contractor at the Contractor's expense. All work shall be in accordance with the utility owner's directions, or by methods recognized as being the standard of the industry when directions are not given by the owner of the utility.

F. Damage to Utilities and Private Property. The Contractor shall protect all utilities and private property and shall be solely responsible for any damage resulting from his construction activities. The Contractor shall hold the Owner and Engineer harmless from all actions resulting from his failure to properly protect utilities and private property. All damage to utilities shall be repaired at the Contractor's expense to the full satisfaction of the owner of the damaged utility or property. The Contractor shall provide the Owner with a letter from the owner of the damaged utility or property stating that it has been repaired to the utility owner's full satisfaction.

G. Water Mains and Services. All water mains and services exposed during construction shall be adequately supported and protected from freezing at all times. Sections of water mains shall not be valved off without first giving the Owner sufficient notification and receiving authorization from the Engineer. Unless otherwise permitted in writing by the Owner, water mains and services shall not be shut off for more than 3 hours. All affected water service customers shall be notified by the Contractor in advance of any interruption of service.

Whenever a water main or service is damaged as a result of the Contractor's operations, the Contractor shall take immediate steps to repair the damage and disinfect all water mains and services contaminated as a result of the damage.

Existing water services from the mains to private property which interferes with trenching operations may be cut and replaced , with Engineers approval, at the Contractor's option and expense provided the requirements for notification, length of interruption, and disinfection specified above are adhered to.

H. Maintenance of Flows. Adequate provisions shall be made for maintaining the flow of sewers, drains, and water courses encountered during construction. Culverts, ditches, fences, crosswalks, and structures which are disturbed by this construction shall be satisfactorily restored to their original condition upon completion of the work.

I. Structures. The Contractor shall exercise every precaution to prevent damage to existing buildings or structures in the vicinity of his work. In the event of such damages, he shall repair them to the satisfaction of the owner of the damaged structure at no cost to the Owner.

J. Overhead Utilities. The Contractor shall use extreme caution to avoid a conflict, contact, or damage to overhead utilities, such as power lines, street lights, telephone lines, television lines, poles, or other appurtenances during the course of construction of this project.

K. Buried Gas and Petroleum Lines. The Contractor shall provide some means of overhead support for buried gas and petroleum lines exposed during trenching to prevent rupture in case of trench caving.

L. Pavement Removal. Where work requires the removal of curb and gutter, concrete sidewalks, or asphaltic or concrete pavement, the pavement or concrete shall be cut in a straight line parallel to the edge of the excavation by use of a spade-bitted air hammer, concrete saw, colter wheel, or similar approved equipment to obtain a straight, square clean break. Pavement cuts shall be 2 feet wider than the actual trench opening as indicated in the Drawings.

M. Survey Markers and Monuments. The Contractor shall use every care and precaution to protect and not disturb any survey marker or monuments, such as those that might be located at lot or block corners, property pins, intersection of street monuments or addition line demarcation. Such protection shall include markings

with flagged high lath and close supervision. No monuments shall be disturbed without prior approval of the Engineer. Any survey marker or monument that is disturbed by the Contractor during the construction of the project shall be replaced at no cost to the Owner by a licensed professional land surveyor.

12. SITE ACCESS

The Contractor shall not unreasonably encumber the site or public rights-of-way with his materials and construction equipment. The Contractor shall comply with all reasonable instructions of the Owner's representative and the ordinances and codes of government agencies regarding signs, traffic, fires, explosives, danger signals and barricades.

A. Makoshika State Park Road will be closed by the Owner for the construction project. Public access will be restricted.

B. Provide for access as needed for the Owner, Owner Representatives, Engineer, safety and emergency personnel and in the park utility companies throughout the project. Keep the road passable by these others during off work periods. Coordinate scheduling for potential of full closure and minimize down time to less than 4 hours.

C. At a minimum provide and maintain construction area closed signs and barricades at the start and end of the project to restrict public access.

13. TRAFFIC CONTROL

A. The Contractor shall schedule his construction operations in a manner which will assure that: 1) the safety and convenience of motorists and pedestrians, and the safety of construction workers, are adequately met at all times; and 2) the project is completed in a manner most beneficial to the project as a whole.

B. The Owner will close Makoshika State Park Road to the public during construction.

14. CONSTRUCTION FACILITIES AND CONTROLS

A. Temporary Utilities. The Contractor shall provide all temporary electrical, lighting, telephone, heating, cooling, ventilating, water, sanitary, first aid, fire protection, and other utilities and services necessary for the performance of the work. All fees, charges, and other costs associated therewith shall be paid for by the Contractor.

B. Barriers.

1. The Contractor shall temporarily remove all signs, fences, barricades, minor structures, and other obstructions that interfere with the prosecution of the work. Removal shall not extend beyond designated construction limits or rights-of-way without first obtaining written authorization from the Engineer.

2. Fences and barricades used for the confinement or exclusion of livestock, animals, or persons shall be replaced at the end of each work day to the extent necessary to perform the restrictive intent of the barrier.

3. Unless otherwise directed by the Engineer or indicated on the Drawings, all barriers so removed shall be replaced following the completion of the work to as good or better condition than existed prior to the start of work. This requirement applies to small trees and decorative shrubs as well as signs, fences, barricades, and minor structures.

4. The Contractor shall replace at his own expense all barriers damaged or destroyed.

C. Security. The Contractor shall provide all security measures necessary to assure the protection of his plant and equipment, products and materials in storage, completed work, the Owner, the public, site safety, and the project in general.

D. Temporary Controls. The Contractor is reminded state, federal, and local laws and regulations require the Contractor to provide controls to limit or prevent nuisance and pollutive work methods and procedures.

15. DISPOSAL OF USED WATER

Disposal of used water shall be the responsibility of the Contractor. Discharges to the surface are subject to permit and regulatory requirements. Discharge of chlorinated water is the responsibility of the Contractor. Discharge to sewer or storm drains must be coordinated with the Owner and secure Engineers approval.

16. SITE DEWATERING

Site dewatering, if required, shall consist of that dewatering necessary to construct the work as specified, including all excavation and embankment. The Contractor shall submit a plan for dewatering to the Engineer. The Contractor shall also be responsible for obtaining the necessary permits for discharge of the dewatering operations.

17. SMOKE AND DUST CONTROL

The Contractor shall have informed himself of all applicable State Board of Health requirements and similar state or federal requirements pertaining to control of or abatement of air pollution. He shall have provided or be prepared to provide such air pollution control measures as are required to comply with the minimum standards established by such agencies.

Hauling of material and transport of equipment along public roadways or through the towns and adjacent other structures and dwellings shall require effective dust abatement procedures. This

also applies to the unloading and placement of spoils material at deposition sites. The Contractor shall utilize environmentally sound methods for watering and/or otherwise chemically treating dust generating surfaces to comply with all applicable legal standards for airborne particulates. Prior to any work, the Contractor shall submit a written plan for dust abatement procedures identifying at a minimum the following:

* Times and nature of dust generating activity on public roads and at deposition sites.
* Nature and chemical characterization of dust abatement materials to be used.
* Method of application of dust abatement materials to be used.
* Time schedule for application of dust abatement materials to be used.
* Availability of equipment and operators for emergency application of dust abatement materials at other than scheduled times.

Watering for dust control is considered incidental to the Contract and shall be performed at no additional cost to the Owner.

18. ENVIRONMENTAL PROTECTION

A. Pollution of natural resources of air, land, and water by operations under this contract shall be prevented, controlled, and abated in accordance with the rules, regulations, and standards adopted and established by the State of Montana and the U.S. Government. The Contractor shall provide such air and water pollution control measures required to comply with the minimum standards established by such agencies.

B. The Contractor shall have informed himself of all applicable State Board of Health requirements and similar state or federal requirements pertaining to control of or abatement of air pollution. He shall have provided or be prepared to provide such air pollution control measures as are required to comply with the minimum standards established by such agencies.

C. Erosion Control: The Contractor shall schedule and conduct operations so as to minimize erosion of soils and prevent sediment from entering the storm drainage system or washing to other low areas. The Contractor shall incorporate all permanent erosion control features into the work at the earliest practicable time, and provide such temporary control measures as may be needed during construction to serve until the permanent features are completed. The Contractor shall submit the Erosion Control Permit Application to the Engineer / Owner for approval details of temporary measures proposed for use. All costs of complying with the above shall be considered incidental to the cost of other contract items and no direct compensation will be made, except as otherwise specifically provided in these Specifications.

D. Construction Activity Storm Water Permit: Contractor is required to obtain permit coverage under the *MPDES General Permit for Storm Water Discharges Associated with Construction Activity* (called "General Permit"). Contractor shall obtain this General Permit coverage from Montana DEQ by providing the

required Notice of Intent (NOI) form, Storm Water Pollution Prevention Plan (SWPPP), application fee and any other documentation required by DEQ.

1. Contractor shall provide proof of General Permit coverage to the Engineer / Owner prior to beginning construction. Contractor shall adhere to all requirements of the General Permit throughout construction, including submitting a Notice of Termination form when construction activity is complete and the site has achieved "final stabilization" (as defined by DEQ).

19. SANITARY FACILITIES

The Contractor shall furnish, install, and maintain ample sanitary facilities for all workers. As the needs arise, a sufficient number of enclosed temporary toilets shall be conveniently placed as required by the sanitary codes of state and local governments. All such facilities and services shall be furnished in strict accordance with existing and governing health regulations. Costs for furnishing, installing, and maintaining sanitary facilities shall be considered incidental to other items of work, and no additional compensation will be allowed.

20. RECORD DRAWINGS

A. The Contractor's Superintendent shall maintain at the project site, a "Record Set of Drawings" showing field changes, as-built elevations, unusual conditions encountered during construction, and such other data as required to provide the Owner with an accurate "as constructed" set of record drawings. The Contractor shall furnish the "Record Set" to the Engineer following the Final Inspection of the Project.

B. The Contractor's final estimate and final payment will not be processed until the "Record Set" of drawings are received and approved by the Engineer.

21. CONSTRUCTION PERMITTING, FEES & REGULATORY REQUIREMENTS

A. The Contractor shall be responsible for <u>obtaining all permits</u> and <u>paying all fees</u> necessary for conductance of the work. Permits may include, but not be limited to, the following:

1. All permits required for storm water discharge and disposal, erosion control, stream impacts, etc.
2. All permits required for dewatering of the construction site

B. <u>Jurisdiction</u>: The performance of this work shall be under the jurisdiction of the following agencies, departments, and standards. Compliance with the requirements thereof is required:

1. Federal Level: United States law.
2. State Level: Montana Department of Environmental Quality; and Montana State law.
3. Local Level: Dawson County, Glendive Montana.

C. Contractor's Responsibility: The Contractor shall familiarize himself with the requirements of all regulatory agencies pertaining to the performance of the work on the project.

D. The Contractor shall secure and pay for all permits, licenses, and fees necessary for the performance of the work. The Contractor shall perform all work in accordance with the regulatory requirements. Any conflict between the Contract Documents and the regulatory requirements shall be brought to the immediate attention of the Engineer.

22. FULL DEPTH RECYCLING WITH CEMENT TREATED BASE

A. FHWA FP-14 Standard Specification, Section 305 Full Depth Recycle with Cement, will be used for this project as modified below. Other cross referenced FHWA FP-14 Specifications apply (see Section 305 and Technical Specifications Contents). All of FHWA FP-14 is available for free at https://flh.fhwa.dot.gov/resources/specs/.

B. Materials.

1. Cement. Use Type V Portland Cement. Use low alkali cement (FHWA FP-14).
2. Mix design. Apply cement as noted in the drawings and as follows: 11% by weight in paved areas; and also 7% in lower sections of unstable areas. This basic mix design was predetermined during the road design process and the Contractor does not need to complete mix design testing as noted in the Standard Technical Specification 305.

C. Verification of Unstable Areas.

1. Perform deflection proof rolling with a loaded tandem axle dump truck or front-end loader. Note locations where deflection of ½-inch or more occur. Notify Engineer of time of profiling to facilitate attendance. Provide list of unstable locations to the Engineer.
2. While performing road reclamation operations note soft and unstable locations.
3. Engineer will approve locations for unstable area construction (Typical Section 2).
4. Do not compact unstable areas.

D. Cement Treated Base Production Start-Up Procedures.

1. Preparatory phase meeting. Conduct a pre-stabilization preparatory phase meeting at least 7 days before the start of stabilizing operations.
2. See Technical Specification.
3. Submit control strip results for Engineers approval.

E. Application of Cement

1. Apply cement uniformly as a slurry, the time from first contact of cement with water to application on the soil shall not exceed 60 minutes. The time from slurry placement on the soil to start of mixing shall not exceed 30 minutes. The dry cement application method is not allowed.
2. Do not add cement when the underlying surface is frozen, muddy, or when conditions allow for excessive loss to eroding or blowing. Begin cement application when the air temperature is above 40 F (5 °C) and is expected to stay above 40 °F (5 °C) for 48 hours.
3. Use approved equipment and dispersal processes to uniformly apply a cement and water slurry without pooling or run off. Equip slurry tanks with an agitator to keep the cement suspended in water. Apply the slurry to the pulverized material within 60 minutes of mixing (starting when the water first contacts the cement). Make successive passes over the material if necessary to obtain the proper moisture and cement content for mixing and compacting.
4. Curing. Cure at least 72 hours prior to placing the next course.

F. Maintenance.

1. The contractor shall maintain the soil-cement in good condition until all work is completed and accepted. Such maintenance shall be done by the contractor at his own expense.
2. Maintenance shall include immediate repairs of any defects that may occur. If it is necessary to replace any soil-cement, the replacement shall be for the full depth, with vertical cuts, using either soil-cement or concrete. No skin patches will be permitted.

G. Curing. Use water curing method, not prime coat.

H. Prime Coat. Prime coat will not be used on the project.

23. ASPHALT, AGGREGATE & MARKINGS

A. Asphalt and Aggregate.

1. Asphalt Concrete Pavement. Use Type B (3/4-inch minus). Use performance graded asphalt binder (PGAB) 64-28.
    a. Job Mix limit for the No. 200 Sieve has a tolerance of +/- 1.5 percent.

2. Place all lifts with a mechanical paver.

B. Pavement Markings. Comply with MDTSS 620 Pavement Marking Application as modified herein.

1. Marking layout to be same as existing markings. Include centerlines, edge lines, words and crosswalks, etc.
2. Apply High Durability Waterborne Traffic Paint as described in Interim Pavement Markings. Include Montana Type 1 or 2 Glass beads.

24. SOILS INFORMATION

Soils information for this project was obtained by S.K. Geotechnical**,** Billings, Montana**,** and documented in a Pavement Evaluation Report dated January 29, 2018. The soil test boring locations are shown on the Construction Drawings and their laboratory test results are included at the geotechnical reporting in the Appendix of these specifications.

25. ESTIMATED QUANTITIES

A. Estimated Quantities. All estimated quantities stipulated in the Proposal and other Contract Documents are approximate and are to be used only (a) as a basis for estimating the probable cost of the work; and (b) for the purpose of comparing proposals submitted for the work. It is understood and agreed that the actual amounts of work done and materials furnished under unit price items may vary substantially from such estimated quantities. The actual quantities will depend on the conditions encountered at the time the work is performed, and the unit prices apply and budget allows.

26. UNIT PRICE WORK

The unit price of an item of Unit Price Work shall be subject to reevaluation and adjustment under the following conditions:

A. if the total cost of a particular item of Unit Price Work amounts to 25% or more of the Contract Price and the variation in the quantity of that particular item of Unit Price Work performed by Contractor differs by more than 10% from the estimated quantity of such item indicated in the Agreement; and

1. if there is no corresponding adjustment with respect to any other item of Work; and

2. if Contractor believes that Contractor has incurred additional expense as a result thereof; or if Owner believes that the quantity variation entitles Owner to an adjustment in the unit price, either Owner or Contractor may make a claim for an adjustment in the Contract Price in accordance with

the General Conditions if the parties are unable to agree as to the effect of any such variations in the quantity of Unit Price Work performed.

B. For this project there are work items that will only be used if necessary, may not be used (example: Road Repair 2), and quantities may be significantly different than estimated on the bid proposal. There will be no additional compensation for the unit price of this item due to a quantity change and units will be measured as provided in the Measurement and Payment section.

27. PROJECT MEETINGS

A. Preconstruction Conference. After the Contract has been awarded, but before the start of construction, a preconstruction conference will be held at a time and place mutually agreed to by the parties. The conference shall be attended by the following: the Contractor and his superintendent; the principal subcontractors; representatives of principal suppliers and manufacturers, as appropriate; the Engineer; Representatives of the Owner; and others as appropriate.

Unless previously submitted, the Contractor shall bring the following submittals to the conference: list of proposed Subcontractors; proposed construction schedule; schedule for submitting shop drawings and other submittals; scheduled procurement dates; construction technique submittal forms (as applicable); preliminary payment schedule; and tentative schedule of values. Work shall not start prior to the Engineer's receipt of these submittals.

B. Progress Meetings. Progress meetings will be held at least every other week to review progress, requests for payment, maintain coordination, update and modify scheduling requirements, and resolve any problems that might develop. The Engineer shall preside at the meeting. These progress meetings may be required more or less often, weekly or monthly, depending on progress and as determined by the Engineer.

C. Daily Log. Provide a daily log to the Engineer electronically. Include daily photos labeled with activity, date and stationing. Note at a minimum workers on the job, equipment used, materials mobilized, work items accomplished, etc.

28. GOVERNING STANDARDS AND REGULATORY REQUIREMENTS

A. Jurisdiction. The performance of this work shall be under the jurisdiction of the following agencies, departments, and standards and compliance with the requirements thereof is required:

Federal Level: United States law; United States Corps of Engineers; Environmental
Protection Agency.

State Level: Montana Code Annotated; Montana Department of Environmental Quality; Dept. of Fish, Wildlife & Parks (SPA); Department of State Lands; the Department of Natural Resources and Conservation; the Montana Building Codes Division; Uniform Building Code, (latest edition); Uniform Plumbing Code, (latest edition); Uniform Mechanical Code, (latest edition); Uniform Fire Code (latest edition); National Electric Code, (latest edition).

Permits. The Contractor must also comply with the requirements of any permits obtained for the project by the Owner. These permits may include stream bed crossing permits, flood plain permits, etc. Copies of any of these permits are available upon request from the Engineer. However, the Contractor shall be responsible for obtaining any permits regarding the discharge of any water related to the construction of this project (this includes a Montana Department of Environmental Quality 3A Permit).

Local Level: City ordinances and regulations.

B. Contractor's Responsibility. The Contractor shall familiarize himself with the requirements of all regulatory agencies pertaining to the performance of the work on the project. The Contractor shall perform all work in accordance with the regulatory requirements. Any conflict between the Contract Documents and the regulatory requirements shall be brought to the immediate attention of the Engineer.

29. WEED SPECIES CONTROL

Prior to mobilizing equipment on the project site, the Contractor shall clean his equipment and vehicles to assure no weeds are imported. If there is an abnormal growth of noxious weeds on a project site after construction as determined by the Owner or local weed control authority, the Contractor will be responsible for weed control for the duration of the contract warranty.

The Contractor shall ensure that all equipment is clean, free of dirt and mud, and dry prior to mobilizing on-site to avoid the spread of invasive species. Any equipment which has been used in or around weeds must be disinfected prior to entering the site.

30. REGULAR HOURS AND WEATHER DAYS

A. Regular Hours. The regular work week shall consist of five working days, Monday through Friday, with regular working hours of 8:00 a.m. to 5:00 p.m. Written requests to perform any work outside of the regular work week or normal working hours for approval, must be delivered to the Owner and Engineer no less than 48 hours prior to the planned start of the work. Engineer and Owner anticipate allowing reasonable revisions (within daylight hours) to the daily work schedule.

B. Weather Days. In the event inclement weather or the aftermath of inclement weather prevents the Contractor from performing any compensable work for a minimum of 60% of the Regular day or other work period approved by the Owner, he may request a credit for that day. No credit for inclement weather will be allowed on non-working days. A request for a weather day must be submitted to the Engineer by the end of each calendar day being requested.

C. Winter Shutdown. In the event of the onset of winter weather, a winter shutdown will be granted upon written request and mutual agreement of the Contractor and Owner. Work will commence in the spring at the earliest possible date.

1. In the event of a winter shutdown all disturbed streets must as a minimum be completed up through the crushed aggregate base course or reclaimed asphalt base course phase, including finished grading and compaction, prior to the winter shutdown being granted.
2. On the Full Depth Recycling (FDR) roadway the Contractor should not mix the cement with the base course material this fall unless they are confident that they can finish the paving of those roads prior to a winter shutdown. In the event that the Contractor mixes the cement with the base material, and the weather prohibits the paving of those roads this fall, the Contractor will be required to protect and maintain the cement blended base over the winter months, in accordance with Special Provision Section 22. Full Depth Recycling with Cement Treated Base.
3. If the weather looks marginal for paving the Contractor is strongly advised to delay the mixing of cement.
4. Do not pulverize more of the existing FDR and overlay the road than the Contractors feel they can comfortably get repaved this fall.

D. Standby Time. No separate payment will be made for standby time, inactive periods beyond Contractor control or inactive periods resulting from requirements of this Contract. Such time will be considered incidental to the required work. Standby time can be expected, but is not limited to waiting for completion of other related contractors work.

31. CONTRACTOR REIMBURSED ENGINEERING COSTS

The Contractor shall reimburse the Owner the full cost of Engineering services in the event the Engineer incurs unscheduled employment necessitated by the Contractor.

Examples of unscheduled employment of the Engineer are the following Contractor actions:

A. Working more than forty (40) hours per week, more than five (5) days per week and Saturdays, Sundays, and holidays.

B. Furnishing materials or equipment not in conformance with Contract Documents necessitating redesign by the Engineer.
C. Working beyond the time of completion established in the Notice to Proceed with Construction.
D. Retests by the Engineer of tests that have failed.
E. Retests by others for tests that require Engineer's presence.
F. Repeated review of submittals and shop drawings that have not been approved.
G. Additional inspection as a result of unacceptable work.
H. Other services that are within the Contractor's control to avoid.

The Engineering fees to be reimbursed by the Contractor shall be according to the following schedule:

A. Labor: At the Engineer's current billable rates, including overhead, as referred to in the Agreement between the Owner and Engineer, plus 15% profit.
B. Other Consultant: At actual cost plus 10%
C. Mileage: 4X4 @ $0.595/mi.; 2WD @ $0.545/mi.
D. Per Diem: Federal or State allowable rate
E. Other expenses and laboratory testing: Actual Cost + 10%
F. Field Testing: Engineer's current billable rate for specific equipment utilized

Contractor shall make payment of these Engineering services by deduction from the project progress payments or final payment or by invoice to the Contractor.

The Engineering contract will be analyzed at the end of the project to determine whether any unscheduled employment of the Engineer, during the schedule contract time, resulted in a cost savings to the Owner. If, as a result of working more than 40 hours per week, five days per week, the Contractor completes the project within the scheduled time, and if the overtime results in a reduced contract time and cost savings to the Owner, no damages will be assessed for the unscheduled employment of the Engineer during the scheduled contract time. Damages will be assessed as stipulated for each day the work remains uncompleted beyond the scheduled contract time.

32. SEQUENCE OF OPERATIONS

Submit a breakdown of the work sequence of operations. Road work is generally anticipated to begin at the end of the project stationing and move toward the Visitors center. Provide a timeline that includes the road broken into at least 0.5-mile sections. Include all culvert work and anticipated work days on each. Update the schedule weekly.

33. SYSTEM COMMISSIONING AND CLEANUP

A. Scope. This section covers the final preparations required to place the various components into operation.

B. Final Conditioning. Before final acceptance is made, the entire work shall be cleaned and conditioned. This shall consist of the following:

1. Roads shall be fine-graded and paved; and
2. Landscaping shall be fine-graded and re-established where necessary.

B. Removal of Construction Equipment, Tools, and Supplies. At the completion of this Contract, before acceptance of the work by the Owner, the Contractor shall remove all of his equipment, tools, and supplies from the property of the Owner. Should the Contractor fail to remove such equipment, tools, and supplies, the Owner shall have the right to remove them at the Contractor's expense.

1. Remove all flags and exposed blue tops.

34. SPOILS DISPOSAL

Contractor is required to dispose of all excess fill materials at an approved disposal area.

35. DRAINAGE WORK

A. Drainage work for this project covers the whole length of the road project from the park entrance to the end of work at the road switchback (STA 132+73). This work will be completed regardless of the length of road contracted.

B. Work is covered by MDTSS (Division 200 & 600) and FHWA FP-14 (Section 303 - Road Reconditioning), as modified herin and detailed below.

C. Culvert Inspections. After cleaning and exposing and preparation of culvert ends for treatment and final grading, notify Engineer for review and approval of planned work. Exposed work may reveal necessary revisions to planned work.

D. Culvert End Treatment Areas. Treatments for each culvert end are described on the project drawings. Work incudes mowing, clearing, grubbing, grading and preparation for erosion control mat and riprap.

1. Culvert cleaning includes removal and disposal of accumulated sediment. Dispose of waste at an off-site location meeting all local, state and federal rules and regulations.
2. Remove foreign material within the structure and accessories by approved methods. Complete work so thorough inspection of the culvert can be conducted on all internal joints and surfaces.
    a. Submit culvert proposed cleaning method.
    b. Provide temporary erosion control during cleaning and discharge of sediment material during the cleaning process.
    c. Complete work without damaging culverts or adjacent ground.
3. Remove debris, vegetation, and earthen material that impedes inlet and outlet channel flow to the structure.

4. Obtain approval from the Engineer before removing trees.
5. Dispose of removed material off-site.
6. Regrade inlet and outlet channels at structures to provide positive drainage. Reshape inlet to direct flow into the structure entrance. Reshape outlet and inlet to provide uniform grades and match existing surfaces. Smooth cut slopes and regrade unvegetated areas and prepare for revegetation and bank protection. Max slope is 2:1 in the impacted area.
7. Impacted surface area for uniform grading shall typically be the culvert diameter in inches, converted to feet, squared (example: 24-inch culvert, 24x24 feet, 576 square feet or 64 square yards). Area shape is commonly elongated in the direction of the inlet or outlet drainages. Minimum uniform grade distance from a culvert inlet or outlet is equal to the pipe diameter in inches, converted to feet (example: for an 18-inch culvert, match existing grade 18 feet up or down the drainage from the inlet or outlet).
8. Patch Rebar. Remove rust and loose materials from exposed metals on existing culverts. Patch with two coatings of coal tar epoxy

E. Erosion Control Mat (Blanket). Use permanent Turf Reinforcement Mat (TRM) with a Natural Fiber Matrix; North American Green SC150; or approved equal.

1. Use erosion control mat (EMAT) in drainages from the ditch invert to the channel top that is construction disturbed and not vegetated. Lay erosion control mat on uniformly graded surfaces, prepared, seeded and fertilized. Ditch depth is as shown on plans and at culvert ends shall be the same elevation as the culvert height (example: a 36-inch culvert has erosion control mat extending to an elevation of 36 inches above the uniformly graded ditch invert).
2. Install according to manufactures recommendations with key trenches on all exposed mat edges.

F. Ditches. Reestablish ditches as shown on the plans and according to FHWA FP-14 Section 303 - Road Reconditioning.

36. MEASUREMENT & PAYMENT

1. Scope. This section describes the method of measurements and basis of payment for all work covered by the Contract Documents. For the purposes of this Contract, this Measurement and Payment Section shall govern and take precedence over all other references to measurement and payment (with exception to any addenda) referenced in these specifications. References to the *Montana Public Works Standard Specifications (MPWSS)* in these Contract Documents are for technical specifications only for items so referenced; the Measurement and Payment provisions of the *MPWSS* do not apply.

2. Bid Prices.

A. The bid price for each item of the Contract in the Bid Proposal shall cover all work shown on the Drawings and required by the specifications and other Contract Documents. All costs in connection with the work, including furnishing all materials, equipment, supplies and appurtenances; providing all required construction support plants, equipment, and tools; constructing and maintaining dewatering systems; and performing all necessary labor and supervision to fully complete the work, shall be included in the unit and/or lump sum prices bid in the Bid Proposal. The amounts shown on the Bid Proposal shall be the contract price.

B. No item that is required by the Contract Documents for the proper and successful completion of the work will be paid for outside of or in addition to the prices submitted in the Bid Proposal. All work not specifically set forth as a pay item in the Bid Proposal shall be considered a subsidiary obligation of the Contractor and all costs in connection therewith shall be included in the prices bid.

3. Retainage. Retainage in the amount of 5% will be withheld from each progress payment.

4. Estimated Quantities. Any estimated quantities stipulated in the Bid Proposal or other Contract Documents are approximate and are to be used; (1) only as a basis for estimating the probable cost of the work and (2) for the purpose of comparing the bids submitted for the work.

5. Incidentals. The following measurement and payment sections do not necessarily name all the incidental items required by the Contract Documents to complete the work. The cost of all such incidentals shall be included in the various related bid items. Final payment will not be made until the work is complete and accepted by the Owner.

6. Method of Measurement.
   A. No measurement of items contained in this Contract will be made on items representing a lump sum bid.
   B. Provide detailed schedule of values for Lump Sum work.
   C. Measurement of items contained in this Contract will be made on the number of items represented by each unit installed and described in further detail in the payment section.

7. Basis of Payment. Base Bid.

A. Mobilization, Bonding & Submittals (May Not Exceed 5% of Total Base Bid):
   * General: This bid item shall include mobilization, bonding, insurance and submittals.
   * Work Included:
     - All labor, tools, equipment, materials, and incidentals necessary to complete the work as shown and specified;

- Transport and set up all equipment, materials and other items needed to complete the project;
- Site safety signage, access coordination, site security, traffic control, staging area preparation and reclamation;
- Bonding and Insurance; and
- Provide all submittals, the construction schedule, and other paperwork required prior to construction start up.

* Measurement: Measurement for mobilization, bonding & submittals shall be one lump sum (LS) item.
* Payment: Payment shall be by the lump sum (LS) item listed on the Proposal. Payment of this bid item will be allowed once the Contractor is fully mobilized, all submittals are received, and bond and insurance certificates have been submitted and approved; thereon 100% payment will be allowed (subject to 5% withholding). This bid item may not exceed five percent (5%) of the total base bid.

B. Road Repair 1 (FDR w CTB)

* General. This bid item shall include the construction of the pavement FDR w CTB shown on the Plan and Profile sheets and as detailed in the General detail sheets of the Construction Drawings.
* Work Included:
  - All labor, tools, equipment, materials, and incidentals necessary to complete the work as specified;
  - Pulverizing the existing pavement, base course and subgrade as shown on the drawings;
  - Shoulder gravel, trail road edge treatment;
  - Remove and replace or install new delineators, for applicable section of roadway;
  - Replace signs, and road markings as needed for roadwork;
  - Construction of the new pavement section including the FDR, CTB, and surfacing materials; and
  - Applying a tack coat as shown and to the edge of the existing pavement prior to paving (where applicable).
* Measurement. Measurement shall be made by the Lineal Foot of Road Repair 1 constructed. Measurement shall be on the road centerline, measured to the nearest foot.
* Payment. Payment shall be by the Lineal Foot of Road Repair 1 constructed.

C. Road Repair 2 (Soft Area FDR w CTB)

* General. This bid item shall include the construction of the pavement FDR w CTB at soft areas as shown on the Plan and Profile sheets and as detailed in the General detail sheets of the Construction Drawings. Work for this item may not apply or may be more than the planned estimate, subject to field verification procedures.
* Work Included:

- All labor, tools, equipment, materials, and incidentals necessary to complete the work as specified;
- Proof rolling to determine location for Soft Area FDR w CTB location;
- Pulverizing the existing pavement, base course and subgrade as shown on the drawings;
- Remove and replace or install new delineators, for applicable section of roadway;
- Shoulder gravel, trail road edge treatment;
- Replace signs, and road markings as needed for roadwork;
- Construction of the new pavement section including the FDR, CTB, and surfacing materials;
- Multiple passes for different CTB cement mixes; and
- Applying a tack coat as shown and to the edge of the existing pavement prior to paving (where applicable).

* Measurement. Measurement shall be made by the Lineal Foot of Road Repair 2 constructed. Measurement shall be on the road centerline, measured to the nearest foot.
* Payment. Payment shall be by the Lineal Foot of Road Repair 2 constructed.

D. Road Repair 3 (Subexcavation w Reconstruction)

* General. This bid item shall include the construction of the pavement Sub-excavation Section Areas shown on the Plan and Profile sheets and as detailed in the General detail sheets of the Construction Drawings.
* Work Included:
  - All labor, tools, equipment, materials, and incidentals necessary to complete the work as specified;
  - Excavation and disposal of the existing pavement, base course and subgrade;
  - Construction of the new pavement section including the "separation" geotextile, subbase, base course, FDR, CTB, and surfacing materials;
  - Replace signs, and road markings as needed for roadwork;
  - Remove and replace or install new delineators, for applicable section of roadway;
  - Applying a tack coat as shown and to the edge of the existing pavement prior to paving (where applicable).
* Measurement. Measurement shall be made by the Lineal Foot of Road Repair 3 constructed. Measurement shall be on the road centerline, measured to the nearest foot.
* Payment. Payment shall be by the Lineal Foot of Road Repair 3 constructed.

E. Utilities

* General. This bid item shall include the utility related work on the project construction as shown on the Plan and Profile sheets and as detailed in the

detail sheets of the Construction Drawings. Utility work applies to the section of road where the road work occurs (Base Bid or Additive Alternate stationing).

* Work Included:
  - All labor, tools, equipment, materials, and incidentals necessary to complete the work as specified;
  - Install steel casing at depth and length specified;
  - Excavation and replacement of materials;
  - Install trench plug;
  - Cap and mark casing ends;
  - Identify existing utility locations and depths at all work including culvert and casing crossings;
  - Utility repair and replacement as necessary, and;
  - Coordinate with utility company and provide submittals.
* Measurement. Measurement shall be one lump sum (LS) item for Utilities.
* Payment. Payment shall be by the lump sum (LS) item listed on the Proposal.

F. Site Drainage Improvements
* General: This bid item shall include all site drainage improvements along the whole road project.
* Work Included:
  - All labor, tools, equipment, materials, and incidentals necessary to complete the work as shown and specified;
  - Cleaning culverts, culvert maintenance;
  - New culverts, excavation, bedding and geofabrics;
  - New culvert trench plugs
  - Replacement culverts, repairs, FETS, and extensions;
  - Fabric and structural backfill;
  - Riprap, new, replacement and reestablishing riprap;
  - Regrading, clearing grubbing, mowing, brush removal;
  - Revegetation, seedbed prep, fertilize, seed, mulch all disturbances;
  - Erosion control mat;
  - Roadside ditch repair and construction;
  - Excess soils, and removed construction materials disposal;
  - Trail excavation and replacement, materials and compaction as shown;
  - Road trail edge treatment;
* Measurement: Measurement for Site Drainage Improvements shall be one lump sum (LS) item.
* Payment: Payment shall be by the lump sum (LS) item listed on the Proposal.

8. Basis of Payment. Additive Alternate 1

A. Road Repair 1 (FDR w CTB)

* General. This bid item shall include the construction of the pavement FDR w CTB shown on the Plan and Profile sheets and as detailed in the General detail sheets of the Construction Drawings.
* Work Included:
  - All labor, tools, equipment, materials, and incidentals necessary to complete the work as specified;
  - Pulverizing the existing pavement, base course and subgrade as shown on the drawings;
  - Shoulder gravel, trail road edge treatment;
  - Remove and replace or install new delineators, for applicable section of roadway;
  - Replace signs, and road markings as needed for roadwork;
  - Construction of the new pavement section including the FDR, CTB, and surfacing materials; and
  - Applying a tack coat as shown and to the edge of the existing pavement prior to paving (where applicable).
* Measurement. Measurement shall be made by the Lineal Foot of Road Repair 1 constructed. Measurement shall be on the road centerline, measured to the nearest foot.
* Payment. Payment shall be by the Lineal Foot of Road Repair 1 constructed.

B. Road Repair 2 (Soft Area FDR w CTB)

* General. This bid item shall include the construction of the pavement FDR w CTB at soft areas as shown on the Plan and Profile sheets and as detailed in the General detail sheets of the Construction Drawings.
* Work Included:
  - All labor, tools, equipment, materials, and incidentals necessary to complete the work as specified;
  - Proof rolling to determine location for Soft Area FDR w CTB location;
  - Pulverizing the existing pavement, base course and subgrade as shown on the drawings;
  - Remove and replace or install new delineators, for applicable section of roadway;
  - Shoulder gravel, trail road edge treatment;
  - Replace signs, and road markings as needed for roadwork;
  - Construction of the new pavement section including the FDR, CTB, and surfacing materials;
  - Multiple passes for different CTB cement mixes; and
  - Applying a tack coat as shown and to the edge of the existing pavement prior to paving (where applicable).
* Measurement. Measurement shall be made by the Lineal Foot of Road Repair 2 constructed. Measurement shall be on the road centerline, measured to the nearest foot.
* Payment. Payment shall be by the Lineal Foot of Road Repair 2 constructed.

C. Utilities

* General. This bid item shall include the utility related work on the project construction as shown on the Plan and Profile sheets and as detailed in the detail sheets of the Construction Drawings. Utility work applies to the section of road where the road work occurs (Base Bid or Additive Alternate stationing).
* Work Included:
  - All labor, tools, equipment, materials, and incidentals necessary to complete the work as specified;
  - Install steel casing at depth and length specified;
  - Excavation and replacement of materials;
  - Install trench plug;
  - Cap and mark casing ends;
  - Identify existing utility locations and depths at all work including culvert and casing crossings;
  - Utility repair and replacement as necessary, and;
  - Power and phone utility stub out, junction box, and pedestal, at Gunners Ridge access;
  - Coordinate with utility company and provide submittals.
* Measurement. Measurement shall be one lump sum (LS) item for Utilities.
* Payment. Payment shall be by the lump sum (LS) item listed on the Proposal.

END OF SPECIAL PROVISIONS

TECHNICAL SPECIFICATIONS

CONTENTS

A. Incorporation of Montana Public Works Technical Specifications:

The following Technical Specifications contained in the Montana Public Works Standard Specifications (MPWSS), Sixth Edition, April 2010, and all subsequent Addendum, are hereby incorporated by reference and made a part of this Contract.

Division 1 – General Requirements

Division 2 - Sitework

B. Incorporation of the Montana Department of Transportation Standard Specifications for Road and Bridge Construction:

The following Technical Specifications contained in the Montana Department of Transportation Standard Specifications for Road and Bridge Construction (MDTSS), 2014 Edition, and all subsequent Addendum, are hereby incorporated by reference and made a part of this Contract.

Division 200 - Earthwork

Division 300 – Aggregate Surfacing and Base Courses

Division 400 – Bituminous Pavements

Section 401 – Plant Mix Surfacing
Section 402 – Bituminous Materials
Section 407 – Tack Coat
Section 410 – Bituminous Surface Treatment

Division 600 - Miscellaneous Construction

Section 610 – Roadside Revegetation
Section 613 – Riprap and Slope and Bank Protection
Section 619 - Signs and Delineators
Section 620 – Pavement Marking Application
Section 622 – Geotextiles

Division 700 – Materials

Section 701 – Aggregates
Section 713 – Miscellaneous Materials
Section 714 – Pavement Marking Materials
Section 716 - Geotextiles

C. Incorporation of the Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects FP-14:

The following Technical Specifications contained in the U.S. Department of Transportation, Federal Highway Administration, Federal Lands Highway, Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects (FHWA FP-14), 2014 Edition, and all subsequent Addendum, are hereby incorporated by reference and made a part of this Contract.

Division 300 Aggregate and Base Courses

Section 301 - Untreated Aggregate Courses
Section 303 – Road Reconditioning
Section 304 – Full Depth Reclamation
Section 305 - Full Depth Reclamation with Cement

D. Technical Specifications Bound Within this Document:

Division 1 – General Requirements

Section 01400 Quality Control and Quality Assurance

Division 2 – Sitework (MPWSS and RPA)

Section 02114 Relocating or removing utility poles, street signs and mailboxes

Division 300 Aggregate and Base Courses (FHWA FP-14)

In the event of a discrepancy between the above referenced specifications (MPWSS, MDTSS, FHWA) and the following Technical Specifications contained within this bound document, the following bound versions shall take precedence.

NOTE: Measurement and Payment (M&P) provisions included in the above referenced Technical Specifications do not apply and are superseded by the Special Provisions of this Contract.

End of Contents

SECTION 01400

QUALITY CONTROL AND QUALITY ASSURANCE

PART 1: GENERAL

1.1 DESCRIPTION

A. This section describes the Contractor quality control testing requirements and quality assurance program.

B. All work will be tested and inspected to insure compliance with the Contract Documents. Complete payment will not be made until the Contractor has demonstrated that the work is complete and will perform as intended.

1.2 REFERENCES

A. The following ASTM publication is a part of this specification.

ASTM E 329 Evaluation of Testing and Inspection Agencies as Used in Construction

PART 2: MATERIALS --- NOT USED

PART 3: EXECUTION

3.1 GENERAL

A. The Contractor shall be responsible for quality control tests and inspections to control production and construction processes. Include in the Contractor quality control system an internal organization, plans, and procedures to produce the specified end product. Assure the system covers all construction operations, both on-site and off-site, and is keyed to the construction sequence. Quality control testing frequency is at the Contractor's discretion, except where test frequencies are specifically required elsewhere in these Specifications for individual products. If quality control testing is specifically required by these Specifications, the results of those tests shall be shared simultaneously with the Contractor and Engineer. Some testing requires the hiring of an independent testing firm as specified.

B. Sampling and testing to assure specification conformance are performed by the Contractor or the Contractor's testing agency for quality assurance testing.

C. The Owner may also select additional third-party testing agency to perform testing. If so, the Owner will pay for (or provide) the quality third party assurance testing.

D. Quality control tests required of the contractor include, but are not limited to, the following tests. Costs associated with these tests shall be paid by the Contractor. All tests requiring the services of a laboratory to determine compliance with the Contract Documents shall be performed by an independent professional testing laboratory, acceptable to the Engineer, and paid for by the Contractor.

1. Initial aggregate quality tests including: stripping tests, volume swell tests, fracture tests, wear tests, sand equivalency and soundness tests on proposed aggregate sources if not taken from a previously-accepted source (with evidence that the aggregate meets these specifications and can be provided to the Engineer).

2. Moisture-density curves of the different types of subgrade, subbase, base courses, and trench backfill material encountered or supplied.

3. Nuclear Densometer compaction testing, performed by a qualified independent testing agency, of the subgrade, subbase, base course, asphalt pavement, and trench backfill materials to establish and maintain the compactive effort required to meet the compaction specifications.

4. See FHWA FP-14 Technical Specification 305 for Conformance Testing requirements.

E. Quality control testing is performed following the standards and frequency in the technical specifications for individual products, or as follows:

The following minimum compaction testing procedures shall apply to all utility and roadway construction projects. A certified operator, or his designated representative, at Contractor's expense, shall be retained to provide the following tests and frequency. Random longitudinal test locations are required. The following are minimum compaction test requirements. For project areas containing less than 300 linear feet of improvements, a minimum of one compaction test for each improvement shall be required for the improvements listed below.

1. For all materials, provide recent gradation and proctors that are representative of the material being used and by a certified testing agency.

<u>Utility Trenches and Underground Structures:</u>

Density test shall be taken upon the first lift of the trench backfill material above the pipe and at every two (2') feet vertically through the trench and at the surface.

A test series consists of the multiple tests, beginning at eighteen (18") inches above the pipe, every two feet vertically through the trench and at the surface as required.

Horizontal Frequency:

Utility Main – At least one field density test series for every 200 lineal feet of utility main and at every road crossing.

Service Lines – At least one field density test series for every service line per utility type.

Open Pit – At least one field density test series for every manhole, water valve, storm inlet, curb inlet, vault, etc.)

Each test location shall be separated horizontally from a prior test location.

Road subgrade:

Gradation test and proctor submitted to Engineer for each existing material type encountered.

At least one field density test series for every 500 square yards of roadway or parking area. A test series consists of three compaction tests at various locations and depths throughout the subgrade.

Subbase Course:

One gradation test for every 200 cubic yards of material placed. Proctor submitted to Engineer for each material type.

At least one field density test series for every 200 cubic yards placed. A test series consists of three compaction tests at various locations and depths throughout the subbase.

Base Course:

One gradation test for every 200 cubic yards of material placed. Proctor submitted to Engineer, for each material type.

At least one field density test series for every 200 cubic yards placed. A test series consists of three compaction tests at various locations and depths throughout the base.

Cement Treated Base: See FHWA FP-14 Technical Specification 305 for Testing requirements.

Portland Cement Concrete:

Contractor shall obtain and submit mix design(s) to Engineer for approval.

Gradation test shall be required for all projects planned to exceed 500 tons of asphalt. Gradation test shall be conducted for each 1,000 tons or 3 days production, whichever is less.

At least one field density test series for every 1,000 tons of asphalt and CTB or 3 days production, whichever is less. A test series consists of three cores in various, random locations upon the asphalt to determine thickness and density.

1. Portland Cement Concrete job-mix formula for any concrete work on the project including, but not limited to thrust blocks, sidewalks, slabs and foundations.
2. The Contractor shall arrange for and pay for an independent laboratory to take and break concrete test cylinders, slump, and air testing as called out in the plans or technical specifications. A minimum of 4 concrete cylinders shall be made and tested for each 20 CY of concrete placed. One cylinder shall be tested at 7-days, two at 28-days, and one retained in reserve for later testing if required.
3. The Contractor shall arrange for and pay for an independent laboratory to prepare a bituminous surfacing job-mix formula and to test for compaction and job-mix compliance during the paving operations.
4. The Contractor shall arrange for and pay for all tests required not specifically identified above as being performed by the Owner.
5. Retesting as provided above.

Asphalt Testing and Inspection Services Provided by the Contractor. The Contractor shall provide the following services as well as those listed on Table 12:

A. The Contractor shall arrange for and pay for an independent laboratory to prepare a bituminous surfacing job-mix formula as called out in the Technical Specifications. Submit to Engineer for approval.

B. The Contractor shall provide the Engineer with a written schedule indicating dates for specific testing and inspection services to be performed. The schedule shall be updated as required to give the Engineer at least one week's advance notice. The Contractor shall notify the Engineer immediately of any change or shall be subject to pay engineering fees as herein defined.

Table 1

QUALITY ASSURANCE PLAN TESTS AND SPECIFICATIONS FOR ROAD-SURFACE PRESERVATION AND SAFETY IMPROVEMENTS MATERIALS TESTING QC/QA AND SUBMITTAL CHECKLIST MAKOSHIKA CREEK ROAD					
Reference	Description	Frequency	Contractor Responsibility	Engineer Responsibility	Information Submitted Yes No
AGGREGATE SOURCE ACCEPTANCE (SUBMITTAL ONLY REQUIRED)					
If not using approved commercial source, then the following aggregate testing will be required.					
ASTM C131 ASTM C88	Los Angeles Abrasion Sodium Sulfate Soundness	1 per source 1 per source	X X		
ASTM D4318	Atterberg Limits	1 per source	X		
ASTM D2419	Sand Equivalent	1 per source	X		
ASTM D5821 ASTM D4791	Fractured faces Flats & Elongates	1 per source 1 per source	X X		
BITUMINOUS PLANT MIX PAVING					
ASTM	Bitumen Certifications	Each Tanker	X		
Asphalt Institute MS-2	Job Mix Formula **(Submittal Only)**	One per oil type and aggregate source	X	Review submittal	
ASTM D6926/6927 AATM D2041	Marshall Density, Stability and Flow, Air Voids	1 test per 1000 tons	X		
ASTM D6307 AASHTO T30	Asphalt Content by Ignition Furnace Method Agg. Gradation from Ignition burnout	1 test per 1000 tons 1 test per 1000 tons	X X		
AASHTO T329	Moisture content of bituminous mixture by oven method	1 time daily	X		
ASTM C566 & D1461	Moisture Content of Aggregate & Mixture	1 time daily	X		
ASTM D2726 ASTM D3549	Cored Bulk Specific Gravity Thickness of Cores	1 set of 2 cores (4” dia.), per 1000 Ton Thickness on all cores	X		
Asphalt Institute MS-2	Voids in Mineral Aggregate (VMA)	Calculated 1 time daily	X		
ASTM D2950	Nuclear In-Place Density	As necessary to achieve specified density **Acceptance for density is by cores only**	X	Review submittal	

E. Testing Results: Results obtained from the Contractor's certified testing lab shall be provided within 2 working days, plus the time normally required to perform the test, and shall be delivered in writing simultaneously to the Contractor, Owner and Engineer. Any delay, in the receipt of these tests shall cause the work to be stopped until results are obtained and analyzed by the Contractor, Owner and Engineer. No concrete or asphalt may be installed until all test results for underlying material have been received and are in accordance with specifications.

F. Performance of Tests and Inspections: The Contractor, Owner, Engineer, and representatives of funding and regulatory agencies may perform periodic inspections and tests to determine compliance with the Contract Documents. The Contractor shall provide qualified manufacturer's representation during tests of equipment and special procedures as required by the Contract Documents.

G. Acceptance and Rejection of Materials: Acceptance and rejection will generally be determined from tests made of the various subbase, and base courses complete and in-place in the field. While the Owner and Engineer may, during the course of construction, make tests at the source or point of production; it is the responsibility of the Contractor to conduct, control and test his production operations in such a manner that the material produced will meet the Specification requirements.

H. Use of Nuclear Densometer for Acceptance Testing: Field density determination, acceptance testing of the subgrade, subbase, base course, and trench backfill materials shall be accomplished using a nuclear gage in accordance with ASTM-D-6938.

I. Inspection:

1. The Contractor shall inspect the work as it is being performed. Any deviation from the requirements shall be immediately corrected. Prior to any scheduled inspection by the Owner or Engineer, the Contractor shall again inspect the work and certify to the Owner and Engineer that he has inspected the work and it meets the requirements of the Contract Documents.
2. The Engineer may observe work and compare the quality of the work with the requirements of the Contract Documents. Any discrepancies noted shall be brought to the Contractor's attention, who shall immediately correct the discrepancy. Failure of the Engineer to detect a discrepancy will not relieve the Contractor of his ultimate responsibility to perform the work as required.
3. Should the Engineer incur additional costs to make additional observations as a result of unacceptable work, the Contractor shall reimburse the Owner for additional Engineering fees at the Engineer's billable rates at the time of subsequent inspections.
4. Observation by the Engineer's representative shall not be considered as authorization to proceed with the work. Work progress and the performance of quality work are the Contractor's responsibility. The Engineer's

observation is for the purpose of determining what work will be paid for and what work will not be paid for. If the Engineer detects a discrepancy between the work and the requirements of the Contract Documents at any time, up to and including final inspection, such work will not be completely paid for until the Contractor has corrected the deficiency.

5. The work will be subject to review by the Owner, whose findings shall be as valid as those of the Engineer. The results of all such observations shall be directed to the Contractor through the Engineer.

J. Independent Services provided by the Contractor: The Contractor shall provide the following services at no additional cost to the Owner:

1. Field location of existing utilities involved in the work.
2. Preparation and certification of all required shop drawings and submittals.
3. Maintenance of project drawings which shall be accurately marked up with changes and conveyed to the Engineer at the completion of construction.

3.2 CONTRACTOR COOPERATION WITH TESTING AGENCY

A. Assure the testing agency personnel have access to all work areas at all times work is in progress. Provide any special facilities or equipment to access work areas at Contractor's expense. Example safe access to construction trenches.

B. Notify the Engineer of the work ready for quality assurance testing to facilitate test method observation. Establish and update the construction schedule to provide the Engineer estimated sampling/testing dates and times.

3.3 PAYMENT FOR TESTING

A. The Contractor shall pay for all quality control testing required in these specifications, including the cost of hiring an independent testing laboratory as necessary.

B. The Owner will pay for additional verification and testing costs, if required.

END OF SECTION 01400

SECTION 02114

RELOCATING OR REMOVING UTLITY POLES, STREET SIGNS AND MAILBOXES

All applicable portions of this specification section in the MPW Standard Specifications shall apply with the following additions, deletions, and/or modifications.

PART 2: PRODUCTS

Delete the entire section and replace with the following:

PART 2: PRODUCTS

2.1 SIGN PANELS

A. Provide aluminum sign panels for all signs.

B. Use Type IV high intensity prismatic sheeting conforming to ASTM D4956-04 on all sign backgrounds. Use Type IV high intensity prismatic sheeting conforming to ASTM D4956-04 on all sign legends and borders requiring reflective material.

2.2 SIGN SUPPORTS

A. Provide galvanized, full punched, 3 pound-per-foot steel "U" channel for all sign posts and foundation stubs.

PART 3: EXECUTION

3.2 STREET AND TRAFFIC CONTROL SIGNS

Delete paragraph H and replace with the following:

H. Drive a 4-foot section of steel "U" channel as a foundation stub at each sign location specified in the drawings. Locate the signs from a minimum of 6 feet to a maximum of 15 feet from the edge of the pavement, measured from the nearest edge of the sign panel. Coordinate with Engineer and obtain Engineer's approval of sign locations prior to installation. Do not damage the stub during installation. If driving the stub to the required depth is not possible, excavate a hole to the required depth and set the stub in concrete. Leave 4 to 6 inches of the stub exposed above finished grade.

Fasten the steel “U” channel sign post to the foundation stub using two Grade 5 bolts. Overlap the sign post and foundation stub 6 inches at the connection. Ensure the sign support is plumb.

Provide a mounting height of 6 feet on all sign installations, measured from the edge of pavement to the bottom of the lowest sign on the sign post.

END OF SECTION 02114

SECTION 02930

COVER SOIL

PART 1: GENERAL

1.1 DESCRIPTION

A. Topsoil shall be called cover soil after it has been excavated and shall be used to cover all areas to be seeded. Actual thickness of salvaged soil is variable and will be field determined during construction.

B. Salvage and Replace On-Site Cover Soil Source: This work consists of site development, excavating, stockpiling, hauling, depositing, spreading, and preparing for seeding all topsoil and subsoil material to be used as cover soil. All areas with available cover soil shall be salvaged during excavation and embankment and replaced on construction-disturbed areas prior to seedbed preparation.

1. All construction disturbed areas shall be revegetated, including road right-of-ways. Slopes to receive salvaged soil will not exceed 3:1.
2. Application rates shall be a minimum of 4 inches at all construction disturbed areas to be revegetated, or as evenly distributed and available soil allows.
3. Imported Cover Soil is not anticipated for this project.

PART 2: MATERIALS

2.1 COVER SOIL

A. Topsoil and subsoil, if present, shall be excavated to a one foot depth or as otherwise determined by the Engineer from areas to be disturbed by project construction. The suitable topsoil and subsoil used as cover soil shall be reasonably free of trash, rocks, hard lumps of soil, stumps, or brush. Noxious weeds shall be pulled and disposed of properly before topsoil stripping. Suitable cover soil shall contain sod or soils with adequate amounts of humus and other organic materials to promote plant growth. Cover soil suitability will be determined by the Engineer. Suitable soil salvaged shall be stockpiled from unsuitable soil and shall be stored in a manner to prevent erosion or contamination.

PART 3: EXECUTION

3.1 SITE DEVELOPMENT

A. Site development performed by the Contractor will include clearing and grubbing as necessary to prepare the soil borrow area for topsoil and subsoil salvage. Clearing

and grubbing consists of removing and disposing of trees, stumps, brush, roots, rock, logs, timber, debris, and other non-soil material.

3.2 COVER SOIL SALVAGE

A. Where visible as distinct strata and greater than 6-inches in thickness, topsoil and subsoil shall be excavated and salvaged in separate operations. The first lift, comprised of existing topsoil, shall be stripped. The second lift, comprised of underlying subsoil, shall then be stripped separately. The exact depths of excavation shall be site specific as determined by visual classification.

B. First lift topsoil and second lift subsoil shall be stockpiled in separate piles and shall be located where they will not impair drainage. Stockpiles shall be shaped and smoothed to facilitate measurement of the piles. Where possible, topsoil and subsoil shall be hauled directly to the prepared areas to be covered.

C. Materials excavated and stockpiled as described herein shall be removed in an operation separate from other excavation. Care shall be exercised to avoid the incorporation of any deleterious subsoils during this work.

3.3 COVER SOIL PLACEMENT

A. Cover soil shall not be placed until the areas to be covered have been properly prepared and all construction work in the area has been completed. All slopes to receive cover soil shall have a rough surface. Smooth slopes to receive cover soil shall have a rough surface. Smooth slopes shall be scarified parallel to the contour to facilitate holding cover soil in place.

B. Ordinary sod or soil containing grass roots shall be broken up before being placed. Broken up sod or soil shall be capable of passing a 2-inch sieve opening.

C. Cover soil material shall be placed on areas to be covered as the soil occurred naturally, with subsoil (second lift) material placed first and underneath the topsoil (first lift) material.

D. As determined by the field Engineer, excess coversoil shall be:

1. Disposed of off-site; or
2. Used as non-critical embankment; or
3. Used to increase topsoil thicknesses where possible.

E. After the cover soil has been spread, all large clods, hard lumps, rocks, large roots over 6 inches in diameter, litter, and other foreign material (exposed iron timbers, etc.) shall be raked up, removed from the seeding areas, and disposed of properly. The cover soil shall be brought to a friable condition to an average depth of 4-inches.

F. The finished elevation of the topsoil shall match the final grades shown on the Drawings or the original ground elevation over pipe trenches.

3.4 SEEDBED PREPARATION

A. Prior to executing the seeding, fertilizing, and mulching work items, the seedbed at all sites shall be prepared so these items can most effectively be completed in conformance with the Technical Specifications. The seeding, fertilizing, and mulching work items shall be executed only after the seedbed has been reviewed by the Engineer.

3.5 SEDIMENT CONTROL

A. Sediment control provisions shall be used whenever work is conducted adjacent to, or in drainages or watercourses to control silt in runoff. Adequate silt barriers or sediment traps shall be used to comply with permit conditions and statutory requirements for all stream-side work, both during and after working hours. Measures used may include staked straw bales, sediment ponds, and/or staked silt fence (Mirafi "Enviro-Fence", or equal). Sediment control measures for uses identified in the plans will be measured and paid for as stipulated in the special provisions. Other sediment control measures needed to comply with permits, regulations, work conditions, contractor operations or otherwise shall be considered incidental to the Work as part of the lump sum bid item Mobilization, Bonding, Insurance, Permitting Compliance & Submittals, and no separate measurement for payment for them will be allowed.

END OF SECTION

SECTION 02931

FERTILIZING AND SEEDING

PART 1: GENERAL

1.1 GENERAL

A. This work shall consist of ground surface preparation; furnishing, applying and incorporating fertilizer into the soil; executing Summer Erosion Control Procedures; furnishing and planting seed; mowing; tracking; and cleanup. The work includes permanent seeding. Fertilizer and seed shall be applied to all project areas requiring revegetation. All construction disturbed areas (excluding paved, graveled, and sodded areas) shall be fertilized and seeded, including road right-of-ways.

1.2 SUBMITTALS

A. The following submittals for construction shall be made in accordance with project submittal requirements as described in the Supplementary Conditions.

1. Fertilizing and Seeding Materials, Equipment and Methods.

1.3 SEED CERTIFICATION

A. Seed certifications shall be submitted to the Engineer prior to any seeding. The Contractor shall also submit a copy of the bill or other documentation from the seed supplier showing actual bulk weights of the individual seed types combined in the mix. The required certifications and documentation shall be provided to the Engineer at least three days prior to seeding.

1.4 INDIGENOUS SEED CERTIFICATION

A. Defined by MCA 80-5-101(4): "Indigenous seeds include the seeds of those plants that are naturally adapted to an area where the intended use is for the revegetation of disturbed sites. These species include grasses, forbes, shrubs and legumes." The Contractor must supply the Engineer with all seed bag tags and a certification from the supplier stating that the seed complies with the Federal Seed Act and the Montana Seed Laws (MCA 80-5-101 through 305).

1.5 FERTILIZER CERTIFICATION

A. Fertilizer shall be delivered in standard size bags of the manufacturer showing weight analysis and manufacturer's name, or in bulk quantities accompanied with written

certifications from the manufacturer stating that the fertilizer supplied complies with applicable specifications.

PART 2: MATERIALS

2.1 INDIGENOUS SEED

A. All seed shall comply with and be labeled in accordance with the Montana Seed Law. MCA 80-5-104(2) states:

"Indigenous seeds, as defined in 80-5-101, in amounts of 1 pound or more whether in package or bulk, must be labeled with the following information."
(a) . . . the statement "labeled only for reclamation purposes";
(b) . . . lot number or other distinguishing mark;
(c) . . . the common name, genus, species and subspecies, when applicable, including the name of each kind of seed present in excess of 5 percent. When two or more kinds of seed are named on the label, the label shall specify the percentage of each. When only one kind of seed is present in excess of 5 percent and no variety name or type designation is shown, the percentage must apply to seed of the kind named. If the name of the variety is given, the name may be associated with the name of the kind. The percentage in this case may be shown as "pure seed" and must apply only to seed of the variety named;
(d) state or country of origin;
(e) the approximate percentage of viable seed, together with the date of test. When labeling mixtures, the percentage viability of each kind shall be stated;
(f) the approximate percentage by weight of pure seed, meaning the freedom of seed from inert matter and from other seeds;
(g) the approximate percentage by weight of sand, dirt, broken seeds, sticks, chaff and other inert matter;
(h) the approximate total percentage by weight of other seeds;
(i) the name and approximate number of each kind of species of prohibited and restricted noxious weed seeds occurring per pound of seed; and
(j) the full name and address of the person, firm or corporation selling the seed.

B. As listed in the Montana Seed Law, seed shall contain no "PROHIBITED" noxious weed seed. The seed shall contain no "RESTRICTED" noxious weed seed in excess of the maximum numbers per pound as specified by MCA 80-50-105 or as specified by the appropriate County Weed Board, whichever is more stringent. The number of seed allowed per pound, for all other noxious weed seeds shown on the "restricted list" will be zero.

C. Seed shall be grown in the North American continent above 41 degrees north latitude. Known varieties whose origin is above the 41st parallel but grown below

are acceptable. All seed shall be a standard grade adapted to Montana conditions. Seed which has become wet, moldy, or otherwise damaged will not be accepted.

D. Calculations of pure "live seed" may be made on the basis of either a germination test or a tetrazolium test in addition to the purity analysis. Seed shall be applied on a pure "live seed" basis. The quantity of pure "live seed" in a 100-pound container shall be determined by the formula: 100 multiplied by germination percentage and this product multiplied by the purity percentage. (For example, if the seed is 85 percent pure and test 90 percent germination, then a 100 percent container would contain 76.5 pounds of pure "live seed.")

2.2 FERTILIZER

A. Fertilizer shall be a soluble commercial carrier of available plant food element or combination thereof. The fertilizer shall be in uniform composition and in good condition for application by suitable equipment. It shall be labeled with the manufacturer's guaranteed analysis as governed by applicable fertilizer laws. Any fertilizer which becomes contaminated or damaged, making it unsuitable for use, will not be accepted.

2.3 WATER

A. Water used for seeding shall be of irrigation quality and free of impurities that would be detrimental to plant growth. Any water required for seeding or mulching shall be at no additional cost to the Owner.

PART 3: EXECUTION

3.1 GENERAL

A. Areas to be seeded and fertilized shall be completed, in reasonable conformity, to specified line and grade prior to seeding and fertilizing and approved by the Engineer.

B. Slopes and areas finished during the period of October 15 through May 31 shall be top soiled and permanently seeded within this time period. The Contractor must obtain Engineer permission to commence topsoil placement and seeding operations. Slopes and areas finished during the period June 1 through October 14 shall be top soiled in accordance with the Cover Soil Specifications, and mulched or otherwise treated in accordance with the Summer Erosion Control Procedure as specified herein. The permanent seeding of these areas shall then commence during the fall at a time approved by the Engineer. The Contractor shall be required to either mulch or otherwise treat in accordance with the Summer Erosion Control Procedure or permanently seed any topsoil area within 15 days of topsoil placement. Application rates for permanent seeding are shown in this Specification under Seed Rate.

C. Seeding of the finished slopes shall require repeated seeding operations until approved by the Owner, and shall not be construed to mean that the required finishing, top soiling, fertilizing, mulching, Summer Erosion Control Procedure, and seeding may be done only once at the convenience of the Contractor. Any additional move-in required will not be paid for separately.

D. It is necessary, insofar as it is practical and feasible, that the seedbed surface, at the time of application of seeds, not be excessively wet, snow-covered, or frozen and be reasonably free of large lumps, clods, and impervious crusts of dirt; that there be no appreciable areas of loose soils which can feasibly be compacted; that the surface, to a depth of approximately 4 inches, not be so tightly compacted that seed cannot begin growth. The Contractor shall treat such areas, to attain, as nearly as practical, the condition described.

E. If seeding is hampered due to standing vegetation, the vegetation shall then be mowed and left lay after seeding. Mowing shall be done, where terrain permits, with equipment using a cutting blade which rotates in a plane parallel to the ground. Whether alive or dead, the vegetation shall be removed if it will prevent good seeding practice.

F. Excessively tight or compacted soils shall be loosened to the minimum depth of 4 inches. Discing, harrowing, or tilling of the soil shall be done at right angles to the natural flow of water on the slopes, unless otherwise approved by the Engineer. Compaction of the soil when required shall be performed by equipment which will produce a uniform rough textured surface ready for seeding and mulching. Compacting of loose soils may be required by the Engineer.

3.2 SEED RATE

A. Range Seed. The following application rates for seed are based on the drill seeding method and intended for seeding areas not to be used as lawn. When the broadcast seeding method or the hydraulic seeding method is used, the application rates listed below must be doubled at no additional cost to the Owner:

Common	Scientific	Variety	Seed Mix (lb. PLS/acre)*
Western wheatgrass	Agropyron smithii	Rosanna	6.0
Bluebunch wheatgrass	Agropyron spicatum	Secar	4.0
Thickspike wheatgrass	Agropyron dasystahyum	Critana	3.0
Slender wheatgrass	Agropyron trachycaulum	Pryor	4.0
Sandberg Bluegrass	Poa sandbergii	High Plains	3.0
Total			20.0

*Pounds "pure live seed" per acre.

B. Lawn Seed. The following application rates for seed are based on the drill seeding method and intended for seeding areas to be used as lawn. When the broadcast seeding method or the hydraulic seeding method is used, the application rates listed below must be doubled at no additional cost to the Owner:

Common	Scientific	Variety	Seed Mix (lb. PLS/acre)*
Perennial Ryegrass	Lolium perenne	Tonga	5.0
Kentucky Blue Grass	Poa pratensis	Ginger	5.0
Canada Blue Grass	Poa Compressa	Reubens	5.0
Creeping Red Fescue	Frestuca rubra	Inverness	5.0
Total			20.0

*Pounds "pure live seed" per acre.

3.3 APPLICATION OF FERTILIZER

A. Fertilizer Rate: Fertilizer shall be applied at the rates specified below. Fertilizer shall be applied to the prepared seedbed prior to seeding or mulching and shall be blended with the cover soil as called for herein, or concurrently with the seed (as "no-till" drills allow).

1. All areas shall be fertilized with an inorganic chemical fertilizer with the following nutrients:
   a. Nitrogen (Elemental) 40 lbs/acre
   b. Phosphorus ($P_2 0_5$) 60 lbs/acre
   c. Potassium ($K_2 0$) 30 lbs/acre

2. All required fertilizer certificates shall be provided to the Engineer a minimum of three days prior to fertilizing. The certification shall include the guaranteed analysis of the fertilizer(s) stated in terms of the percentages of nitrogen (N), available phosphorus ($P_2 0_5$) and potash ($K_2 0$) in that order.

B. Mechanical or hydraulic methods of application are acceptable so long as a uniform application at the specified rate is accomplished. Fertilizer shall be applied prior to seeding. The application method is subject to the submittal review process.

C. The fertilizer shall be incorporated into the soil by discing, raking, or shallow plowing to the full depth of the topsoil or to a maximum depth of 6 inches, whichever is less. Exceptions will be made for seed drills that are capable of incorporating the fertilizer and seed directly into the seedbed. In no instance shall subsoil be incorporated into the seedbed as a result of this operation. Fertilizer shall be incorporated with equipment operated at right angles to the slope of the land.

D. If the Contractor is required to perform the Summer Erosion Control Procedure, fertilization will be completed at the time of permanent seeding. The application methods and methods for incorporating the fertilizer into the seedbed shall be specified herein.

3.4 SEED DISTRIBUTION

A. Seed shall be applied to the conditioned seedbed no longer than 48 hours after the seedbed has been conditioned. Broadcast or hydraulic seeding methods shall not be used during adverse weather as determined by the Engineer. The applied seed, regardless of the method of application, shall not be covered by a soil thickness greater than 1/2-inch in depth.

B. Seeding by Drill. Seeding equipment used for applying grass seed must be designed, modified or equipped to regulate the application rate and planting depth of grass seed. If equipment for sowing cover crop seed is not equipped with press wheels, the

seed shall be compacted with a cultipacker immediately after the ground has been drilled. Seed must be uniformly distributed in the drill hopper during the drilling operation. Acceptable drills are: custom seeders, furrow drills, disc drills, or no till drills. All grass establishment equipment shall be operated normal to the slope drainage.

1. Planting depth shall be regulated by depth bands or coulters. The drill box shall be partitioned by dividers no more than 24 inches apart, in order to provide for more even distribution on sloping areas. A drill shall be no wider than the width of the area over which it is to operate.

2. The rows of planted seed shall be a maximum of 8 inches apart and shall be at right angles to the natural slopes.

C. Broadcast Seeding. Seeding by hand or mechanical broadcasting will be permitted on areas inaccessible to drills or impractical to seed by other prescribed methods. Broadcast seeding requires the approval of the Engineer.

D. Hydraulic Seeding. Hydraulic seeding equipment may not be used. Seed and mulch will be applied in separate and distinct operations except for the following:

1. When using the hydraulic seeding method, the Contractor must provide 1 pound of wood fiber or organic mulch per each 3 gallons of water in the hydraulic seeder as a cushion against seed damage. The mulch used as a cushion may be part of the total required mulch with the remainder applied after the seed is in place.

2. When hydraulically applying mulch in a separate operation, the Contractor may mix the seed with the fertilizer if his hydraulic seeding equipment is capable of uniformly mixing water, fertilizer, and seed--in that order--and power blowing or spraying the mixture uniformly over the seedbed. <u>THIS OPTION OF MIXING FERTILIZER AND SEED WITH MULCH MAY ONLY BE APPLIED ON SLOPES STEEPER THAN 2:1</u>. After blending, the slurry shall be applied to the seedbed within 45 minutes after the seed has been added to the water/fertilizer mixture. If the slurry cannot be applied within the specified 45 minutes, it shall be fortified, at no cost to the Owner, with the correct ratio of seed to the remaining slurry and a new 45-minute time frame established for applying the fortified mixture.

3. The Contractor will be required to use extension hoses to reach the extremities of slopes.

4. The Contractor shall remove any equipment tracks on the seedbed prior to final mulching. The Contractor shall use a rake, small harrow, or other acceptable means to remove the tracks.

3.5 TRACKING

A. Tracking will be required on hydroseeded or broadcast areas where mulch crimping cannot be accomplished and where hydromulching will be accomplished. Exceptions will be allowed for small areas (0.1 ac.) not accessible to hydroseeding equipment.

B. Tracking shall be accomplished using a tracked vehicle equipped with grousers sufficient to groove the surface to at least 1/2-inch. The tracking vehicle shall be operated so as to completely cover the surface with grouser marks. All grousers marks shall run perpendicular to the natural slopes. The tracking vehicle shall be operated alternately between forward and reverse on each pass to eliminate damage to the seedbed resulting from 180 degree skid turns.

C. If the area is seeded by hydraulic methods, tracking of the slopes shall be done at such time when the surface has had sufficient time to dry. The length of time established will be at the discretion of the Engineer.

3.6 SEEDING DATES

A. Seeding shall be permitted from October 15 through April 30.

3.7 SUMMER EROSION CONTROL PROCEDURE

A. In the event the construction is completed after April 30 but before October 15, cover-soiled areas shall then be either mulched immediately with a vegetative mulch of straw or hay, applied at a rate of 2,000 pounds per acre or a soil stabilizer applied at the manufacturer's recommendation with a hydroseeder. The mulch shall be anchored into the seedbed. A "no-till" drill with "no-till" coulters may be used to seed and fertilize directly into the mulched areas during permanent seeding after the October 15 date. If a "no-till" drill (Brillion seeder, or equal) will not be utilized for permanent seeding, the seedbed preparation, fertilizing, seeding and mulching must be conducted in addition to and after Summer Erosion Control Procedure mulch application. Areas treated with a soil stabilizer must also follow the provisions, after the October 15 date, for permanent seeding.

B. Cost for all summer erosion control installations will be considered incidental. No additional compensation will be allowed for this work item.

END OF SECTION

Section 305. — FULL DEPTH RECLAMATION WITH CEMENT

Included in its entirety. See Special Provisions for Modifications.

Description

305.01 This work consists of pulverizing an existing pavement and base in-place, adding crushed aggregate if required, mixing this material with cement and water, and shaping and compacting the mix to produce a stabilized base.

Material

305.02 Conform to the following Subsections:

Crushed aggregate	703.06
Hydraulic cement	701.01
Water	725.01(c)

Construction Requirements

305.03 Proportioning. Collect representative samples of the pavement and base from the project. Process and blend these material to achieve a gradation representative of the in-place pulverized material.

Estimate the median cement content by mass to meet the requirements of Table 305-1. At this median cement content and at cement contents 2 percent above and below this median, determine the optimum moisture content, maximum density, and the parameters included in Table 305-1.

Table 305-1
Soil-Aggregate-Cement Mix Design Parameters

Material or Property	Requirement
Unconfined compressive strength, ASTM D1633, Method A(1)	
Average strength (3 specimens)	200 psi (1.4 MPa) min.
Maximum strength of a single specimen break	400 psi (2.8 MPa) or less
Loss in mass, AASHTO T 135 & AASHTO T 136, 12 cycles	14% max.

(1) At 7-day cure at 70 °F (21 °C) according to ASTM D1632.

Submit a mix design for approval 30 days before production which includes the following:

(a) Optimum cement content conforming to the requirements of Table 305-1;

(b) Maximum density and moisture content at the optimum cement content according to AASHTO T 134, minimum of 4 points;

(c) Source of each component material;

(d) Results of all tests and applicable charts and graphs;

(e) Gradation and proportion of imported crushed aggregate;

(f) 200-pound (90-kilogram) sample of the pavement, base, and imported crushed aggregate, if requested; and

(g) 20-pound (9-kilogram) sample of Portland cement, if requested.

Begin production only after the mix design is approved. Submit a new mix design if the CO requests due to a change in material.

305.04 General. See Subsection 304.03.

305.05 Production Start-Up Procedures.

(a) Preparatory phase meeting. Conduct a pre-stabilization preparatory phase meeting at least 7 days before the start of stabilizing operations according to Subsection 153.04(a).

(b) Control strip. Provide 7 days notice before beginning production.

On the first day of production, stabilize a 1000-foot (300-meter) control strip, one-lane wide, at the designated lift thickness and mix design proportions. Construct the control strip on the project at an approved location.

Construct the control strip using construction procedures intended for the entire project. Take nuclear gauge density readings behind each roller pass to determine the roller pattern necessary to achieve the specification requirements in Subsection 305.10. Cease production after construction of the control strip until the stabilized base layer and the control strip are evaluated for acceptance.

Repeat the control strip process until an acceptable control strip is produced. See Subsection 106.01 for the disposition of material in unacceptable control strips. Accepted control strips may remain in place and will be accepted and measured as a part of the completed base. When a control strip is accepted, full production may begin.

Use these start-up procedures when changing construction procedures, when resuming production after a termination of production due to unsatisfactory quality according to Subsection 106.04, or the beginning of a new construction season.

305.06 Adding Crushed Aggregate. See Subsection 304.04.

305.07 Pulverizing. See Subsection 304.05.

305.08 Applying Cement. Do not add cement when the underlying surface is frozen, muddy, or when conditions allow for excessive loss to eroding or blowing. Begin cement application when the air temperature is above 40 °F (5 °C) and is expected to stay above 40 °F (5 °C) for 48 hours. Apply cement by one of the following methods:

(a) Dry method. Use a metered mechanical spreader to uniformly apply the cement. Use canvas (or similar) skirts around the spreader box to minimize dust.

(b) Slurry method. Use approved equipment and dispersal processes to uniformly apply a cement and water slurry without pooling or run off. Equip slurry tanks with an agitator to keep the cement suspended in water. Apply the slurry to the pulverized material with 60 minutes from time water first contacts the cement. Make successive passes over the material if necessary to obtain the proper moisture and cement content for mixing and compacting.

305.09 Mixing. Begin mixing within 30 minutes after cement application. Use a road reclaimer conforming to Subsection 304.05. Add water as necessary to adjust the moisture content of the mixture to within 2 percent of optimum as indicated in the approved mix design. Continue mixing until the cement is uniformly distributed within the in situ material creating a homogeneous full depth layer. Complete mixing within 1 hour of the cement application.

305.10 Compacting and Finishing. Compact the processed material uniformly to at least 95 percent of maximum density as determined from AASHTO T 134. Furnish rollers sized and configured to achieve the required compaction and finishing. Operate rollers according to the manufacturer's recommendations. Compact the processed material full width by rolling from the sides to the center, parallel to the centerline of the road. Along curbs, headers, walls, and places not accessible to the roller, compact the material with approved tampers or compactors.

During compaction and final grading maintain the moisture content of the mixture to within 2 percent of optimum. Do not leave areas of stabilized material uncompacted or undisturbed for more than 30 minutes. Complete compaction within 1 hour after mixing.

Finish the compacted surface according to Subsection 301.06 to produce a surface that is smooth, dense, and free of compaction planes, ridges, or loose material. Clean the compacted surface of loose material, dirt, or other deleterious material by approved methods. Complete finishing operations within 4 hours from the start of mixing including corrections to irregularities in the surface.

305.11 Construction Joints. When cement application operations are delayed or stopped for more than 2 hours, make a transverse construction joint by cutting back into the completed work to form an approximately vertical face. Tie new work into the completed work by remixing approximately 36 inches (900 millimeters) of the completed course.

305.12 Curing. Cure the layer at least 1 day before placing the next course by one of the methods below:

(a) Water method. Keep the surface continuously moist by applying water through a spray bar equipped with nozzles producing a fine, uniform spray. During the first 24 hours of curing, use a water truck with side spray to avoid driving on the newly stabilized layer.

(b) Prime coat method. Seal the surface by placing an inverted prime coat according to Subsection 411.06(b). Provide and maintain a continuous film over the surface.

If approved by the CO, allow local automobile traffic on the cement stabilized layer 4 hours after finishing operations are complete. Limit traffic speeds to 20 miles (30 kilometers) per hour. Stop traffic if there is surface marring or deformation. Do not allow truck traffic (other than equipment necessary to complete the next course) on the cement stabilized layer until the next course is placed.

305.13 Maintenance. Maintain the cement stabilized layer to the correct line, grade, and cross-section until placement of the next course. If the cement stabilized layer loses stability, density, or finish before placement of the next course, reprocess, recompact, and add cement as necessary to restore the strength of the damaged material.

Overlay the stabilized base within 14 days after compacting.

305.14 Acceptance. See Table 305-2 for sampling, testing, and acceptance requirements.

Crushed aggregate will be evaluated under Subsection 106.03.

Cement will be evaluated under Subsections 106.02 and 106.03.

Construction of full depth reclamation with cement will be evaluated under Subsections 106.02 and 106.04.

Prime coat will be evaluated under Section 411.

Measurement

305.15 Measure the Section 305 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

Measure crushed aggregate under Section 302.

Measure prime coat under Section 411.

Measure removal and disposal of unsuitable material under Section 203 or 204.

Payment

305.16 The accepted quantities will be paid at the contract price per unit of measurement for the Section 305 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 305-2
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Mix Design									
Full depth reclamation (FDR) with cement mixture	Measured and tested for conformance (106.04)	All	–	Subsection 305.03	1 per submitted mix design	Existing roadway	Yes	Minimum 30 days before production	–
Production Start-up (control strip)									
FDR with cement material	Measured and tested for conformance (106.04)	Gradation	–	AASHTO T 27	3 minimum	Behind reclaimer before compaction	No	Upon Completion of test	Minus 2-inch (50-mm) sieve requirement only
		Moisture-density (max density)	–	AASHTO T 134	1 minimum	"	Yes	"	Minimum 4 points per proctor
		Moisture content (in-place)	–	AASHTO T 255	3 minimum	In-place after compaction	No	"	–
		Density	–	AASHTO T 310 or other approved methods	Subsection 305.05(b)	"	"	"	–

Table 305-2 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production									
FDR with cement material	Measured and tested for conformance (106.04)	Moisture-density (maximum density)	–	AASHTO T 134	1 per change of material	Behind reclaimer before compaction	Yes	Before using in work	Minimum 4 points per proctor
		Density	–	AASHTO T 310 or other approved procedures	1 per 2,000 yd^2 (1,700 m^2)	In-place after compaction	No	End of shift	–
	Process control (153.03)	Gradation	–	AASHTO T 27	Minimum 1 per 3500 yd^2 (3000 m^2)	Behind reclaimer before compaction	"	Upon completion of test	Monitor percent passing the 2-inch (50-mm) and No. 4 (4.75 mm) sieves
		Moisture content (in-place)	–	AASHTO T 255 or other approved methods	"	In-place after compaction	"	"	–
		Unconfined compression strength (7-day)	–	Table 305-1	Minimum 1 per day	Behind reclaimer before compaction	"	7 days	7-day cure
Finished Product									
FDR with cement material	Measured and tested for conformance (106.04)	Surface tolerance & grade	–	Subsection 301.06	Determined by the CO	Completed FDR surface	No	Before placement of next layer or as requested	–

END OF SECTION 305

PAVEMENT EVALUATION REPORT

Makoshika State Park Road Improvements
Glendive, Montana
Project 17-3612G

Submitted by

2511 Holman Avenue
P. O. Box 80190
Billings, Montana 59108-0910

Prepared for

Robert Peccia & Associates
P. O. Box 5653
Helena, Montana 59604-5653

January 29, 2018

SK GEOTECHNICAL

2511 Holman Avenue
P. O. Box 80190
Billings, Montana 59108-0190
p: 406.652.3930; f: 406.652.3944
www.skgeotechnical.com

January 29, 2018

Project 17-3612G

Mr. Robert Morton, PE (4)
Robert Peccia & Associates
P. O. Box 5653
Helena, Montana 59604-5653

Dear Mr. Morton:

Re: Pavement Evaluation, Makoshika State Park Road Improvements, Glendive, Montana

The pavement evaluation for the above-referenced project has been completed. The attached report contains the following information:

- Results of the nine soil borings performed along the existing pavement being considered for reconstruction or rehabilitation, as well as one pedestrian bridge boring.
- Results of laboratory tests performed on subgrade and base samples, including property tests as well as analytical laboratory tests to evaluate the presence of dispersive soils along the project.
- Recommended pavement design including the following options:
  - Total reconstruction for ***new*** plant mix surfacing (PMS) and ***new*** base course placed over separation fabric
  - Full-depth reclamation (FDR) with additional aggregate
  - Only FDR
  - FDR with cement treated base (CTB)

Thank you for using SK Geotechnical. If you have any questions regarding this report or require additional services, please contact Greg Staffileno at (406) 652-3930.

Sincerely,

Gregory T. Staffileno, PE
Senior Engineer

Dustin P. Hutzenbiler, PE
Reviewing Engineer

Attachment:
Geotechnical Evaluation Report

Table of Contents

Table of Contents Continued

A. Introduction

A.1. Project

The State of Montana is planning to reconstruct or rehabilitate the first 2.5 miles of Makoshika State Park Road. Makoshika State Park is located on the southeast side of Glendive, Montana. Robert Peccia & Associates (RPA) is the civil engineering firm designing the project.

A.2. Purpose of this Evaluation

The purpose of the pavement evaluation was to assist RPA in designing pavement improvements along Makoshika State Park Road. We are also providing preliminary geotechnical recommendations related to the proposed pedestrian bridge crossing Cains Coulee.

A.3. Scope

The desired scope of services was discussed with State of Montana employees during the interview process on October 3, 2017. On October 31, 2017, we submitted a proposal to RPA containing our recommended scope of work based on our understanding of the project at that time. That same day, Mr. Robert Morton, PE, of RPA, authorized us to proceed in accordance with the proposal. Eventually, RPA provided us an Agreement for Subconsultant Services dated January 18, 2018.

Our scope of services was limited to:

- Field reconnaissance of the existing pavement and directly adjacent topography by a geotechnical engineer.
- Staking the boring locations.
- Coordinating the locating of underground utilities near the boring locations.
- Conducting nine penetration test borings to a depth of 5 feet in the existing pavement and one penetration test boring to a depth of 40 feet at the pedestrian bridge crossing.
- After drilling through the existing pavement section, performing dynamic cone penetrometer tests on the subgrade to assist us in evaluating in situ subgrade strength parameters.
- Collecting bag samples of the existing asphalt pavement millings, base course, and subgrade for various laboratory testing.

- Returning the samples to our laboratory and conducting six classification tests, three moisture-density and California bearing ratio (CBR) tests, sulfate tests on six subgrade samples and three base course samples, and dispersive salt group of tests on three subgrade samples.
- Analyzing the results and formulating recommendations for earthwork and alternative pavement sections as well as preliminary recommendations related to the pedestrian bridge foundations.
- Discussing the project with Mr. Morton.
- Submitting a pavement evaluation report containing logs of the borings, our analysis of the field and laboratory tests, and recommendations for earthwork and pavement sections for the roadway improvements.

Our scope of services did not include geotechnical evaluation of landslides situated along the project or retaining walls/guardrails along the roadway for portions of the roadway directly adjacent to the vertical bank of Cains Coulee.

A.4. Documents Provided

RPA provided us with the following documents for preparation of this report:

- Makoshika State Park Interview Package
- Road Plans from the 1984 Makoshika State Park Roadway Project
- Road Plans from the 1993 Makoshika State Park Road Project
- A sheet showing the Makoshika Park water line extension in 1991.
- A pavement history drawing prepared by DOWL Engineering, which a portion is attached to this report. We wish to point out that this drawing should be considered approximate and has not been confirmed.

A.5. Locations and Elevations

The locations of Borings ST-1 through ST-9A were selected by our personnel. These borings were performed along the 2.5-mile roadway being considered for improvement, and were generally spaced every 0.2- to 0.3-miles apart. The borings were initially staked in alternating east and westbound lanes. Once utility locates were performed, however, we found utilities were generally located in either the eastbound or the westbound lanes, and therefore, some of the borings had to be offset into the other lane.

When this occurred, the offset location was designated by the suffix "A" after the boring number. Borings ST-3A, ST-5A, and ST-8A had to be moved. Boring ST-9A also had to be moved due to black ice being located on the roadway in the switchback area near the end of the project.

On November 8, 2017, after arriving on the site to perform the borings, we met with Mr. Chris Dantic with Montana Fish, Wildlife and Parks. Mr. Dantic indicated they had decided to move the pedestrian bridge further west than the initially selected location. Therefore, Boring ST-10 was performed at this location.

Photographs of Borings ST-1 through ST-10 are attached showing the existing pavement and topography. As mentioned above, Borings ST-3A, ST-5A, and ST-8A had to be moved so the locations indicated in the photographs were moved to the other lanes.

Ground surface elevations at Borings ST-1 through ST-10 were provided by RPA.

B. Results

B.1. Logs

Log of Boring sheets indicating the depths and identifications of the various soil strata, the penetration resistances, laboratory test data, and water level information are attached. It should be noted the depths shown as boundaries between the strata are only approximate. The actual changes may be transitions and the depths of the changes vary between borings.

Geologic origins presented for each stratum on the Log of Boring sheets are based on the soil types, blows per foot, and available common knowledge of the depositional history of the site. Because of the complex eastern Montana depositional environments, geologic origins are frequently difficult to ascertain. A detailed evaluation of the geologic history of the site was not performed.

B.2. Site Conditions

As the Boring Location Sketch indicates, Makoshika State Park is located on the southeast side of Glendive, Montana. The paved portion of the road begins at the entrance on the west side then extends east and southeast for approximately 2 1/2 miles. The roadway is basically situated in the valley floor of Cains Coulee, which has a relatively deep intermittent streambed channel. Ridges and draws are situated next to the coulee and roadway up towards the end of the project. Approximately 2 miles into the park, Makoshika State Park Road travels along switchbacks up to the top of Radio Hill Road. It is our understanding that some landslide movements in this switchback area have been stabilized by installing a

tieback anchor system. This work was completed within the last several years. The existing pavement conditions and geologic hazards observed along the alignment are discussed in more detail below.

B.2.a. Pavement Condition. Based on our observations, the first third and last third of the pavement along the project are generally in poor condition while the middle third is in fair condition. When considering these pavement surfaces are 20 to 30 years old, they have actually performed reasonably well. It is our understanding DOWL-HKM and Morrison-Maierle have been involved in the numerous paving projects along the project since 1984. A summary of these pavement projects has been attached to this report. This drawing should be considered approximate and has not been confirmed.

Transverse cracks were observed along the existing pavement surface at intervals ranging from about 5 to 100 feet, but typically from about 10 to 40 feet. Most of these transverse cracks have been crack sealed, as can be seen in the attached project photographs. Longitudinal cracking along the edge had occurred in isolated areas, as well. Rutting was observed in the driving lanes throughout most of the project. The rut depths typically ranged from 3/4 inch to 2 inches, but in some cases, were up to about 3 inches. Numerous isolated areas of alligator cracking were also apparent along the project. We also observed numerous patches along the project where pavement failures have likely occurred in the past. Some gravel-surfaced areas were also present along the alignment. In these areas, pavement failure had occurred, and the pavement surface had yet to be repaired. These pavement failures are discussed in more detail below.

B.2.b. Geologic Hazards. The roadway is situated along the valley floor of Cains Coulee adjacent to the intermittent streambed and at the toe of adjacent hills. According to the attached Geologic Map, the valley floor consists of alluvium deposits (Qat). Underlying the alluvium and in the adjacent hills are the Ludlow Member of the Fort Union Formation (Tfld) and Hell Creek Formation (Khc), which typically consist of sandstone, shale, and claystone. Bentonitic layers are also commonly present in these formations. The 1998 Geologic Map does not indicate that there are landslides located in these formations. Based on our observations, however, numerous landslides are situated along the entire project. As previously indicated, landslide movement in the switchback areas near the end of the project have been stabilized by a recent tieback project performed by another consulting firm. These landslides are readily observable by using Google Earth and can even be seen on the attached Boring Location Sketch. Based on our observations, almost every ridge situated along the south side of the roadway has a head scarp just below the top of the ridge, and the landslides extend down to the valley floor. Therefore, the roadway is situated at the toe of these landslides, and in some instances, crosses the landslides, which has resulted in pavement distress. In particular, pavement distress in the vicinity of Boring ST-7 and in the switchback area from about Milepost 2.3 to 2.5 are due to landslide movement. These landslides represent a geologic hazard to the roadway. Stabilizing these landslides is economically not feasible, and

it is therefore necessary to assume landslide movement can cause roadway distress in the future. Geotechnical evaluation and mapping of these landslides is not included in our scope of services.

Another geologic hazard associated with the roadway is the proximity of Makoshika State Park Road to the intermittent stream channel. This stream channel is relatively deep and, in some cases, appears to be about 15 to 30 feet deep. Erosion and stream flows have resulted in the streambank being near vertical in many areas. As can be seen in Photos 14 and 15, Makoshika State Park Road travels directly adjacent to these near vertical streambanks in several areas. Due to the lack of a shoulder and/or guardrail, the vertical bank represents a hazard to traveling motorists.

Another geologic phenomenon situated along the project is dispersion holes. As can be seen in Photos 16 and 17, voids/holes are situated in the bedrock and alluvial soils as well as fill materials along the project. Identification and testing to better evaluate the dispersive nature of these soils is discussed later in this report. Our analysis did indicate the soils are dispersive. Dispersive soils are primarily clays and silts which deflocculate or become suspended in the presence of water, allowing them to be transported elsewhere. This process then leaves a void or cave, which can be relatively small, as shown in Photo 16, or relatively big, as shown in Photo 17. The relatively small hole shown in Photo 16 is directly adjacent to the pavement and represents a hazard to motorists and pedestrians.

B.3. Existing Pavement and Subgrade

B.3.a. Summary Table. Table 1 following this page summarizes the existing pavement and subgrade conditions at Borings ST-1 through ST-9A along the rehabilitation/reconstruction extent of the project. The existing pavement and subgrade conditions are discussed in more detail below.

B.3.b. Existing Pavement. As can be seen in Table 1, the existing plant mix surfacing (PMS) ranged in thickness from 1 inch to 4 1/4 inches, but was primarily about 2 1/2 to 3 inches thick. Beneath the existing PMS, the thickness of underlying base course varied, however, it was relatively consistent with the previous pavement sections as identified by the pavement history sketch. For the first third of the project, the borings indicated the existing base course was only 2 1/2 to 3 1/4 inches thick, which is consistent with the anticipated base thickness of 3.6 inches. Near the middle and end of the project, the base thickness ranged from 5 1/4 to 8 inches thick, which is also consistent with the anticipated 6 inches of base. Boring ST-6 encountered approximately 12 inches of existing base over a separation fabric, which was also anticipated based on the 1999 project.

Table 1. Existing Pavement and Anticipated Subgrade Conditions

Boring	ST-1	ST-2	ST-3A	ST-4	ST-5A	ST-6	ST-7	ST-8A	ST-9A	**Average**
Date Drilled	11/8/17	11/8/17	11/8/17	11/8/17	11/8/17	11/8/17	11/8/17	11/8/17	11/8/17	
Location	See BLS	See BLS	See BLS	See BLS	See BLS	See BLS	See BLS	See BLS	See BLS	
Existing PMS	4¼"	3"	3¼"	2½"	3"	3"	1"	3"	2½"	**3"**
Existing Base/Subbase	7¼"[2]	3¼"	2½"	6"	5¼"	10½" over Fabric	---	5½"	8"	**5½"**
Total Thickness	**11½"**	**6¼"**	**5¾"**	**8½"**	**8¼"**	**13½"**	**1"**	**8½"**	**10½"**	**8½"**
As-Built Pavement Sections	Constructed 1984 2.5" PMS over 3.6" Base (6" total)			Constructed 1996 3" PMS over 6" Base (9" Total)		Constructed 1999 3" PMS over 12" Base over Fabric	Constructed 1999 3" PMS over 6" Base (9" Total)		Not Available	
Subgrade[1]										
Description	Silty Sand	Silty Sand to 3' over Lean Clay	Sandy Lean Clay to 1½' over Silty Sand	Sandy Lean Clay	Silty Clay to 1½' over Silty Sand	Lean Clay	Clayey Sand to 2' over Lean Clay	Sandy Lean Clay to 1½' over Silty Sand	Fat Clay	
ASTM Class	SM	SM	CL to SM	CL	CL-ML to SM	CL	SC to CL	CL to SM	CH	
N-Values	30, 14	10, 6	14, 12, 5	11, 7	15, 9	16, 6, 2	4, 10	8, 6, 13	8, 9	
Consistency	Medium Dense	Loose	Stiff to Loose	Rather Stiff to Medium	Stiff to Medium Dense	Stiff to Soft	Very Loose to Rather Stiff	Medium to Loose	Medium to Rather Stiff	
Moisture Content	5.4%, 5.3%	9.4%, 16.0%	12.5%, 12.6%	19.7%, 17.7%	10.7%, 17.7%	8.2%, 14.9%	20.7%, 29.2%	11.6%, 7.1%	26.3%, 20.9%	
Optimum Moisture Content	13.0%	13.0% / 15.0%	15.0% / 13.0%	15.0%	~12% / 13.0%	15.0%	13.0%	15.0% / 13.0%	16.2%	
Risk of Subgrade Failure During Total Reconstruction or FDR[3]	Low	Medium	Medium	High	Medium	Medium	High	Low	High	

[1]Anticipated subgrade that will be present beneath the proposed pavement section.
[2]3¼" Base Course over 4" Subbase Course (3" Minus)
Borings ST-6 and ST-7 not included in average.
[3]FDR: Full Depth Reclamation

In summary, the average existing pavement section along the project is indicated below.

Existing PMS	3 inches
Existing Base/Subbase Course	5 1/2 inches
Total Thickness	**8 1/2 inches**

B.3.c. Subgrade. The boring logs in Appendix 1 outline more details about the soil stratum encountered by each boring. A portion of these soils are summarized in Table 1 and indicated the subgrade primarily consisted of silty sand, sandy lean clay, and silty clay. Near the end of the project, fat clay was encountered in Boring ST-9A. Penetration resistances generally indicated the silty sands were primarily loose to medium dense and the clays were found to be rather stiff to medium consistent. The table also contains a summary of in-place moisture contents versus optimum moisture contents to assist us in evaluating subgrade conditions during construction. In Borings ST-4, ST-7, and ST-9A, the clays were found to be over optimum moisture content and are considered wet. These subgrade conditions and the risk of the subgrade failing during construction are discussed in more detail later in this report.

B.4. Pedestrian Bridge

Boring ST-10 was performed at the south abutment of the proposed pedestrian bridge. A boring on the north abutment was not performed because it was inaccessible to conventional drilling equipment. Boring ST-10 encountered 1 foot of organic clay topsoil underlain by sandy lean clay and sandy silt alluvium to a depth of 7 feet. Decomposed sandstone consisting of clayey sand was then encountered to 14 1/2 feet where sandstone bedrock was encountered to a depth of 33 1/2 feet. Shale bedrock was then encountered to the boring's termination depth of about 39 feet, where auger refusal occurred.

Penetration resistances in the clay alluvium indicated it was medium to rather stiff, and in the sandy silt alluvium, was loose. The clayey sand decomposed claystone was found to be medium dense to very dense by soil consistency standards. The sandstone bedrock was judged to be soft to medium hardness by bedrock standards and would be considered very dense by soil consistency standards. The underlying shale bedrock was also judged to be soft to moderately hard hardness.

Observing the vertical bank along the north abutment indicated similar alluvium underlain by decomposed sandstone and sandstone. Based on the surface elevation of Boring ST-10, we surveyed the top of the decomposed sandstone at elevation 2131 and the top of the sandstone at elevation 2128. These elevations are relatively consistent with those elevations recorded in Boring ST-10.

B.5. Groundwater Observations

Groundwater was not encountered in any of the shallow Borings ST-1 through ST-9A performed in the existing pavement to a depth of 5 1/2 feet while drilling. We should point out that in Boring ST-6, fabric was encountered beneath the base course, which may indicate shallow groundwater could be present in

this area. In the switchback area, it is our understanding that shallow groundwater has been reported, and it is likely contributing to the landslides.

In pedestrian bridge Boring ST-10, groundwater was encountered at a depth of 24 feet in the sandstone bedrock. We should point out that groundwater levels in the pedestrian bridge area will likely fluctuate in unison with water levels in the intermittent stream directly adjacent to this area. Snow melt, rain, and run-off could also affect groundwater levels.

B.6. Dynamic Cone Penetrometer Results

After drilling through the PMS and base course, dynamic cone penetrometer (DCP) tests were performed on the subgrade. These tests evaluate subgrade strength and can be used to estimate in-place CBR and resilient modulus.

The test results are attached. The tests typically extended 3 feet into the subgrade and indicated the subgrade strength typically decreased with depth. Using published correlations and the manufacturer's software, CBR values generally ranged from 3.7 to 17.0, but typically ranged from 3.7 to 9.8.

B.7. Laboratory Tests

The results of the laboratory tests performed by our firm on soil samples from the borings are presented on the boring logs and in Appendix 1. These tests primarily consisted of classification (Atterberg limits and grain size), moisture-density (Proctor), and CBR tests. Sulfate and the dispersion salt group of tests were performed by Energy Laboratories of Billings, Montana. These test results are included in Appendix 2. Penetration test samples from all of the borings were tested for moisture content, and the results are indicated on the Log of Boring sheets.

B.7.a. Subgrade Property Tests. Subgrade property tests were performed on a total of six samples from the borings, and the results are summarized in Table 2 below.

Table 2. Summary of Subgrade Laboratory Tests

Boring	Depth (feet)	Classification			ASTM Class	Proctor		CBR
		LL	PI	P_{200} (%)		MDD (pcf)	OMC (%)	
ST-1	1 – 4	NP	NP	30	SM	112.0	13.0	7.3
ST-4	1 – 4	27	12	59	CL	---	---	---
ST-6	1½ – 4	26	9	71	CL	113.5	15.0	6.9
ST-9A	1½ – 4	53	36	78	CH	111.9	16.2	1.0
ST-10	5½ – 6½	NP	NP	56	ML	---	---	---
ST-10	24½ – 25½	27	10	22	SC	---	---	---

See Descriptive Terminology for acronyms.

B.7.b. Sulfate Tests. Six subgrade samples and three base course samples were selected for sulfate tests. The results are summarized in Table 3 below.

Table 3. Summary of Sulfate Tests

Boring	Depth (feet)	Sample	Percent Sulfate	Ettringite/Thaumasite Risk
ST-1	1 – 4	Subgrade	ND	Low Risk
ST-3A	1 – 3½	Subgrade	0.03%	Low Risk
ST-4*	1 – 4	Subgrade	ND	Low Risk
ST-6*	1½ – 4	Subgrade	ND	Low Risk
ST-7	1 – 4	Subgrade	0.19%	Low Risk
ST-9A*	1½ – 4	Subgrade	0.30%**	Medium Risk
ST-2	---	Base	ND	Low Risk
ST-6	---	Base	0.03%	Low Risk
ST-9A	---	Base	0.12%	Low Risk

*Samples also tested for Dispersive Salt tests, see Appendix 2.
**A quality control split tested, sulfate = 0.29%

When soils are mixed with calcium based projects, such as Portland cement, they can form ettringite and/or thaumasite due to a chemical reaction. The American Association for State Highway and Transportation Officials (AASHTO) Method of Test T290 (Modified) outlines the level of risk associated with stabilizing soils having varying sulfate concentrations. As indicated above, the sulfate tests indicate this risk is low to medium for the samples tested. These results are somewhat surprising when considering eastern Montana soils typically have high sulfates.

The above sulfate tests indicate the subgrade soils have severe corrosion potential to concrete. We recommend Type V cement be used.

B.7.c. Dispersion Analysis and Tests. As previously indicated, holes and caves were observed adjacent to the pavement in numerous areas along the project, some of which are shown in the photographs. We therefore selected three subgrade samples for more intense dispersion testing. The test results and analysis are included in Appendix 3 and discussed in more detail below.

Subgrade soil samples from the project were tested in the lab for dispersion, both mechanical and chemical. Mechanical dispersion testing included pinhole dispersion, crumb, and double hydrometer tests. Chemical dispersion testing included pH, conductivity, cation exchange capacity (CEC), total

dissolved salts (TDS), sodium adsorption ration (SAR), exchangeable sodium percentage (ESP), and exchangeable magnesium percentage (EMgP).

Pinhole test results ranged from non-dispersive to dispersive. Crumb testing indicated moderate to severe dispersion. Double hydrometer results ranged from intermediate to dispersive. Since the mechanical methods are testing slightly different mechanisms of erosion and dispersion, each of the three sample locations scored differently in the three mechanical methods. Boring ST-9A performed the most consistently dispersive, with Boring ST-6 moderate to dispersive, and Boring ST-4 non-dispersive (non-erodible) in the pinhole, to moderate in the crumb and dispersive in the double hydrometer. Results are attached in Appendix 3.

Clays consisting mainly of calcium and magnesium maintain opposite charges and their attractive particles resist erosion and dispersion. Clays higher in sodium have weaker or repulsive charges, offering little to no resistance to erosion and dispersion. At the Makoshika State Park Road site, salt test results for each sample indicate a moderate to high ESP and SAR, with enough ESP+EMgP to classify each sample as dispersive. Results and plots are attached in Appendix 3.

B.7.d. Collapse Test. The result of the consolidation/collapse test performed on the thin-walled tube sample obtained from Boring ST-10 from 5 1/2 to 6 1/2 feet is also attached. The sample collapsed about 3 percent when it was inundated under a load of 950 pounds per square foot (psf). This is a moderate to high value, and indicates the alluvial soils are moderately to highly collapsible. Compression under a load increase of 1,500 psf was about 3 percent, which was also a moderate value.

The initial moisture content and dry density of the sample were determined as part of the test. The initial moisture content of the sample was 14.2 percent, indicating it was moist. The initial dry density of the sample was 81.1 pounds per cubic foot (pcf). This is a very low dry density, and further indicates the alluvial soils are highly collapsible.

C. Analyses and Recommendations

C.1. Proposed Construction

The proposed project is intended to reconstruct or rehabilitate Makoshika State Park Road from the entrance gate up to the new pavement located along the switchbacks, approximately 2.5 miles in length. Alternative pavement sections have been requested by the State of Montana to evaluate the best value for the project when considering budget constraints. The project will also include drainage improvements primarily in the form of deeper, more defined drainage ditches along each side of the roadway. This is recommended to improve surface water run-off and to carry run-off away from the new pavement surface.

At this time, design of the project is still in the preliminary stages, and detailed traffic information has not been provided. We were informed the average daily traffic (ADT) in 2016 was 178.5 vehicles per day, and growth was expected, especially if additional campgrounds were added along the project.

C.2. Discussion

C.2.a. Pavement Section Alternatives. Numerous pavement section alternatives for total reconstruction and rehabilitation are included in the following report. Total reconstruction with new PMS over new base course placed on a separation geotextile should be considered, and may be most cost effective when considering local contractors can be utilized. Rehabilitation alternatives include full-depth recycling (FDR) of the in-place materials, with additional aggregate, and with cement. Rehabilitation of existing pavement sections typically requires a specialized contractor having a reclaimer to pulverize the existing materials, which would result in more mobilization.

Regardless of the pavement section chosen for the project, there is a risk unstable subgrades could be encountered during construction. Unstable subgrades are those subgrades which cannot support the conventional heavy rubber-tired construction equipment and the subgrade and base course cannot be compacted to specification. As previously indicated in Table 1, the risk of unstable subgrades was considered high in Borings ST-4, ST-7, and ST-9A, or three out of the nine borings representing 33 percent of the alignment. Unstable subgrades will require a much thicker pavement section to support construction equipment.

The scheduling of the construction activities for the roadway will also have a major impact on the extent of unstable subgrades for the project. If construction work is scheduled in the spring or early summer, snow melt, run-off, and rain storms can all contribute to wetting of the prevalent clays along the alignment. When clays become wet, their strength is reduced and they are much more likely to become unstable, especially when subjected to heavy repetitive construction equipment traffic. On the other hand, if construction can be scheduled in the late summer or fall, drier conditions would generally be expected, which are more conducive to reducing the risk and extent of unstable subgrades. In our opinion, the construction for the project should be scheduled during the late summer or preferably the fall to reduce this risk of encountering wet subgrades and when considering the budget limitations.

C.2.b. Pedestrian Bridge. It is our understanding recent decisions have been made to eliminate the proposed pedestrian bridge from the current project, although it is likely to be added in the future. RPA is therefore unable to give us final structural loads, abutment elevations, span length, or other design parameters for the bridge. This information is required to provide geotechnical recommendations for the pedestrian bridge. Additional analysis and recommendations can be provided once this design has been developed.

Preliminary recommendations related to the pedestrian bridge, however, are being provided for future considerations. As previously indicated, our fieldwork and laboratory analysis indicated dispersive soils are present along the alignment, which should be considered highly erodible. Viewing the intermittent streambanks, scour analysis should be performed and will likely help assist in determining the best foundation system for the pedestrian bridge. In our opinion, a relatively small diameter drilled pier foundation extended down into the sandstone bedrock would be the best type of foundation for the pedestrian bridge to provide resistance to erosion and scour. We anticipate two 18- to 24-inch diameter drilled piers at each abutment extended through the decomposed sandstone and 5 to 10 feet into the underlying sandstone bedrock will provide more than sufficient capacity to support the pedestrian bridge.

Another alternative to consider would be supporting the pedestrian bridge on a conventional spread footing foundation. For this approach, the footing must be extended through the collapsible alluvial soils down to bear 1 to 3 feet into the decomposed sandstone, which was encountered at a depth of 7 feet in Boring ST-10. Once design information is provided, bearing capacity and settlement of a spread footing foundation can be analyzed. We wish to point out, however, a shallow foundation, such as spread footings, would be subjected to scour and erosion.

C.2.c. Geologic Hazards. As previously indicated, geologic hazards are situated along the Makoshika State Park Road. These geologic hazards include landslides, vertical streambanks adjacent to the roadway, and dispersion holes. Detailed geotechnical reconnaissance and identification of these geologic hazards was not included in our scope of services nor performed for the project. It is readily apparent some of the landslides are causing pavement distress along the project, particularly in the vicinity of Boring ST-7 as well as near the end of the project along the switchbacks. Stabilizing these landslides would require a significant geotechnical work to evaluate alternatives such as tiebacks, which were used for the switchback stabilization project previously mentioned. Geotechnical evaluations for landslides require deep borings, not only performed with truck-mounted or tracked drill rigs, but possibly platform drill rigs, as well. The borings are completed with inclinometers installed to allow measurements of the failure planes. Samples are taken from the borings for laboratory shear testing. This information is then utilized to perform detailed slope stability analysis to evaluate the feasibility of stabilizing the landslide. Not only is the geotechnical evaluation for landslides very expensive, but then stabilizing the landslide is significant. In our opinion, the cost of the geotechnical work needed for these landslides as well as stabilizing them would be considerable, and exceed the budget limitations on the project. Therefore, we have assumed the State of Montana recognizes the presence of these landslides along the project and their inherent risks to cause distress to the roadway.

Other geologic hazards include the vertical banks of the adjacent intermittent streambed. Consideration should be given to installing guardrails where the roadway's close proximity to the streambanks is considered too risky. Retaining walls can be used to provide additional clearance. The dispersive holes

and caves are another risk. Dispersive soils are prevalent throughout the entire area. We are not aware of any mechanical means of stabilizing dispersive soils due to their inherent nature to become suspended whenever flowing water is present. Non-woven geotextile fabrics can be used to help reduce the effects of dispersive soils, however, due to their filtering capabilities.

C.3. Pavement Analysis

C.3.a. Traffic Analysis. A detailed traffic analysis for the project has not been performed. We were provided with preliminary traffic data indicating the ADT in 2016 was 178.5 vehicles per day. Using this information, we performed a simplified traffic analysis available on DARWin™, a computer program based on the *1993 AASHTO Guide for Design of Pavement Structures*. The following parameters were entered into DARWin to perform a simple equivalent single axle load (ESAL) calculation.

Initial performance period (years): 20
Initial two-way daily traffic (ADT): 178.5
Percent heavy trucks (ADT) FHWA Class 5 or greater (%): 2.5
Number of lanes in design direction: 2
Percent of all trucks in design lane (%): 100
Percent trucks in design direction (%): 100
Average initial truck factor (ESALs/truck): 1.0
Annual truck factor growth rate (%): 0.0
Annual truck volume growth rate (%): 4.0
Growth: simple

Total calculated cumulative ESAL: 44,986
Total daily ESAL: 6.16

Daily ESALs less than 10 indicate low traffic volume along the roadway. With low volume, we typically use lower reliability and other parameters for design.

C.3.b. Methodology. The alternative pavement sections were analyzed using an Excel worksheet based on the *1993 AASHTO Guide for Design of Pavement Structures*, which has been included in Appendix 1. The AASHTO pavement design method is based on numerous input parameters, each affecting the required total pavement thickness for a low volume road. The following design input parameters were used to evaluate appropriate pavement sections.

- 18-kip ESALs over initial performance: 44,986
- Initial Serviceability: 3.7
- Terminal Serviceability: 2.0
- Reliability Level (%): 75
- Standard Deviation: 0.45

- Roadbed Resilient Modulus (psi): 4,500

The roadbed resilient modulus is a representation of the subgrade strength. Three samples were selected for CBR tests and resulted in CBR values of 1.0, 6.9, and 7.3. A typical design CBR value is one standard deviation below the mean. The mean is 5.1 and the standard deviation is 3.5, resulting in a 1.6 value. In our opinion, this value is too low for this low volume road. The DCP results typically ranged from 3.7 to 9.8. Reviewing all of these test results, it is our opinion a design CBR value of 3.0 should be used for the project, primarily represented by the lean clay subgrade prevalent along the project. This equates to a roadbed resilient modulus of 4,500.

Based on our analysis, we calculated a Structural Number (SN) of 2.28 will be required to support a 20-year pavement design for the project. We analyzed numerous pavement section alternatives for this project as indicated below. Each of these pavement sections is then discussed in more detail later in this report, followed by a discussion of some advantages and disadvantages of each.

1. Total Reconstruction: This is the conventional pavement section including new PMS over new base course placed on Class 2 non-woven separation fabric.
2. Full Depth Reclamation (FDR) with Additional Aggregate: FDR is recommended to take advantage of the existing pavement and aggregate along the project. Because the average existing pavement and aggregate is slightly too thin, however, an additional 2 inches of aggregate will be necessary for this approach to achieve a 20-year design.
3. Only FDR: For the thin existing average pavement section, we evaluated only FDR to determine the expected life span with this approach. FDR with 3 inches of new PMS will result in a 16-year design life.
4. FDR with Cement-Treated Base (CTB): FDR with CTB is another method to consider to take advantage of the existing pavement and base course along the alignment. Adding the cement to the pulverized mixture will increase the base strength to support anticipated traffic.

C.3.c. Total Reconstruction. Total reconstruction with new PMS and new base course should be considered for the project as well as any new pavement development areas. After the existing pavement has been removed, we recommend the following crushed base course (CBC) section.

New PMS	3"
New CBC, 1½-inch Minus	8"
Class 2, Non-woven Geotextile (6- or 8-ounce)	yes
Total Thickness	**11"**

C.3.d. FDR with Additional Aggregate. The soil borings indicate there is not enough average pavement structure to meet a 20-year FDR approach. Therefore, additional CBC will need to be added to the surfacing prior to the reclamation/pulverization of existing materials. We recommend adding 2 inches of virgin 3/4-inch minus CBC on top of the existing pavement prior to reclaiming/pulverizing. We then recommend pulverizing/reclaiming to a maximum depth of 8 inches, then regrading and recompacting the pulverized mixture to grade. It should then be followed by 3 inches of new pavement, resulting in the following pavement section.

New PMS	3"
Pulverized/Reclaimed Base Course	7"
Existing Base Course (not disturbed)	2½"
Total Thickness	**12½"**

One disadvantage to FDR with additional aggregate is it will cause the grade of the roadway to increase. We anticipate this final pavement surface will likely be about 3 to 4 inches higher than the existing pavement surface, although the advantage is it will inherently improve drainage. Additional aggregate at the shoulders, however, could be necessary.

C.3.e. FDR Only. We also evaluated FDR without adding additional aggregate, then surfacing with 3 inches of new PMS. Our analysis indicates this will provide a pavement having a 16-year design life rather than 20-year, which is normal. This approach can be considered, however, it must be recognized that this pavement section will not perform as well as the other alternatives presented in this report. If normal pavement requires annual maintenance after 12 to 15 years, this thinner section will require maintenance after eight to ten years.

C.3.f. Unstable Areas. The following recommendations are related to unstable subgrades encountered during construction of the preceding three alternatives: C.3.c. Total Reconstruction; C.3.d. FDR with Additional Aggregate; and C.3.e. FDR Only.

C.3.f.1. Sensitive Subgrades and Water. A common problem in roadway construction is encountering unstable subgrades. Unstable subgrades are those subgrade soils that are too soft and wet, and cannot support heavy rubber-tired construction equipment or be compacted to specification. The borings indicate the primary subgrade along the project will be silty sand, sandy silt, lean clay, sandy lean clay, silty clay, and fat clay, which are all considered highly moisture sensitive. If these soils become wet, their shear strength is reduced, and they will become unstable, particularly if they are subjected to heavy rubber-tired repetitive construction traffic. Water is a trigger mechanism for creating these unstable subgrades, which could be encountered during construction year-round. Water can seep through existing cracks in the PMS, saturating the underlying base course and subgrade. Water can also be running laterally from the lack of roadside ditches, saturating portions of the subgrade. Higher groundwater levels were reported in

the switchback portion of the project. During construction, it could rain or snow melt could be occurring, which can also saturate these sensitive subgrades. Numerous other unapparent sources of water could also be present. Unstable subgrades can also be created during construction by heavy rubber-tired equipment, poor drainage, and other factors that are difficult to control.

C.3.f.2. Identification and Extent. We recommend the following indicators be used to identify unstable subgrades.

- For total reconstruction, subgrade deflects 1/2 inch or more when proof rolled with a loaded tandem axle dump truck or front-end loader.
- For FDR approaches, the top of the reclaimed base course deflects more than 1/4 inch.
- The subgrade or reclaimed base course cannot be recompacted to *Montana Public Works Standard Specifications* (MPWSS) because it is deflecting beneath the compaction equipment.
- The subgrade contains excessive deleterious or organic materials.

The extent of these unstable subgrades is difficult to estimate when considering the limited number of borings along the project. Table 1 indicated three of nine borings had a high risk of encountering unstable subgrades during construction, or approximately 33 percent.

If construction activities occur in the spring or early summer, we recommend assuming 30 to 50 percent of the alignment could encounter unstable subgrades requiring a thicker total reconstruction pavement section as described below. On the other hand, if construction can be scheduled during the late summer or fall, we anticipate the extent of unstable subgrades could be approximately 15 to 25 percent of the project.

C.3.f.3. Geosynthetic Reinforced Sections. Several alternatives are available to repair unstable subgrades. The contractor should be consulted for repair alternatives related to unstable subgrades. The least expensive method is to avoid the area and allow it to dry out. Consideration can be given to scarifying the subgrade to promote drying. Eventually, the clay soils would dry out, the subgrade can be recompacted to specification, and the pavement section and new PMS constructed on top of it. This method, however, can take several weeks or longer, and is dependent on favorable weather. It is also much more difficult to allow subgrades to dry out beneath reclaimed base courses, i.e., the recommended FDR sections.

Another alternative to more quickly repair excessively soft subgrades is to use high performance geosynthetics as part of the pavement structure. Subgrade stabilization sections using Tensar TX5 and Tencate Mirafi RS 380i geosynthetics are recommended for the project. Substitutions are not recommended. If they are to be considered, we recommend they be submitted by a registered Professional Engineer in the State of Montana along with the appropriate pavement analysis. When unstable subgrades are encountered, we recommend the pavement sections indicated in Table 4 below.

Table 4. Unstable Subgrade Pavement Sections

	Option 1 Tensar Geogrid	**Option 2 Tencate Mirafi RS 380i**
Plant Mix Surfacing	3"	3"
Crushed Base Course	18"	20"
Tensar TX5 Geogrid	Yes	---
6-ounce Class 2 Non-woven Fabric	Yes	---
Mirafi RS 380i	---	Yes
Total Thickness	**21"**	**23"**

C.3.g. FDR with CTB.

C.3.g.1. Discussion. CTB with ***new*** aggregates is commonly used on Montana Department of Transportation (MDT) projects. It is our understanding these pavement sections have been performing well. CTB projects comprised of existing pavement and base course with FDR, however, has been used on a very limited basis in Montana. We recognize this approach may be more cost effective for the roadway, but must emphasize that its use in Montana has been limited, ***and selecting qualified contractors is critical***. For this approach, a cement treatment mix design is necessary to evaluate the ratio of necessary cement to be added to the recycled aggregates. SK Geotechnical is performing this mix design, which takes about two months. The results will be presented in an addendum. For budgeting purposes, we anticipate 5 to 7 percent cement by weight will be necessary to meet strength requirements.

C.3.g.2. Recommended Thickness. Our analysis indicates 3 inches of new hot mix asphalt pavement placed over a minimum of 7 inches of recycled CTB is needed. However, reshaping of the aggregate surface prior to paving is needed to improve the roadway width. When considering the reshaping and regrading, we anticipate the following reclamation along the project.

- Reclaiming/pulverizing the existing pavement, base course, and subgrade to 8 to 9 inches (3/4-inch minus material).

- Reshape and regrade to achieve required roadway width, adding new 3/4-inch crushed base as necessary to achieve grade.
- Apply mix design percent cement (hydrated, slurry cement preferred due to local winds) and reclaim/pulverize to 7 inches.
- Recompact CTB to specifications and allow for proper cure.
- Apply tack coat and sand blotter as necessary to top of recycled CTB.
- Place 3 inches of new hot mix asphalt pavement.

For this approach, the following pavement section will then be provided.

Hot Mix Asphalt Pavement	3"
Reclaimed CTB	7"
Total Thickness	**10"**

C.3.g.3. Thicker Cement-Treated Section for Unstable Areas. Three of nine borings encountered potentially unstable subgrades along the alignment. Repairing unstable areas when constructing FDR with CTB was discussed with a local contractor several years ago. Although site conditions will dictate the best approach, the following general approach is recommended.

- Determine the extents of unstable areas by the following criteria:
    - While performing the first reclamation/pulverization pass, record areas where reclaimer gets bogged down, and
    - After completing the first FDR pass, perform proof rolling on top of the reclaimed base with a loaded tandem axle dump truck or front-end loader. Where deflection of 1/4-inch or more occurs, area should be considered unstable.
- In unstable areas only, perform a second pass with reclaimer to 14 inches with 3 percent cement to create a low-strength thicker lift for bridging.
- Compact and allow to cure for a minimum of 72 hours. (We realize compacting 14 inches will be difficult, however, it will be better than what is there.)
- A third pass is then performed in conjunction with the remaining road, in this case to a depth of 7 inches with mix design percent hydrated cement, compact, allow to cure, then place new pavement surfacing.

This will then result in the following thicker cement-treated section in unstable areas.

Hot Mix Asphalt Pavement	3"
Reclaimed CTB and Subgrade	14"
Total Thickness	**17"**

C.4. Pavement Section Advantages and Disadvantages

C.4.a. General. Determining which of these four alternatives is best for the roadway is relatively difficult, and will most likely come down to cost, especially when considering the budget restraints. A brief discussion of some advantages and disadvantages from a geotechnical perspective is indicated below. Numerous other advantages and disadvantages exist as well, and should be considered.

C.4.b. Total Reconstruction. Total reconstruction will result in all new pavement and base course, and assuming normal Quality Control and full-time inspection, the materials will be controlled and documented, resulting in the expected long-term performance. One disadvantage is construction equipment will ride directly on the subgrade, increasing the risk and extent of unstable subgrades. Repairing unstable subgrades requires a much thicker section placed on a high-performance geotextile, as previously addressed.

C.4.c. FDR. An advantage of FDR with or without additional aggregate is it results in less construction traffic and the traffic is mostly riding on the recycled base course rather than the subgrade. This slightly decreases the extent of unstable subgrades. Unstable areas are repaired with the same thicker section placed on high-performance geotextiles. A major disadvantage of FDR is unknown material consistency and thickness across the length of the project. As previously indicated, information provided indicates there are at least five separate pavement sections along the project, and unexpected variations are quite likely and could result in additional costs. There are also less qualified contractors capable of performing FDR, so costs could be higher.

C.4.d. FDR with CTB. FDR with CTB also has the advantage of less traffic, but more traffic is needed to add and mix the cement than FDR with or without additional aggregate. Material inconsistencies have less of an impact because the cement will increase the strength of reclaimed pavement and existing base courses as well as intermixed subgrades. A major disadvantage is there are even less qualified contractors performing FDR with CTB in Montana, it is just not yet common practice. Specialized contractors typically have higher costs, especially if they have to mobilize from out-of-state. The learning curve of local, less experienced contractors developing this capability could result in additional costs and delays.

C.5. Specifications

For the most part, we recommend all earthwork, subgrade preparation, base course, and PMS be specified and constructed in accordance with MPWSS. The exception is FDR with CTB. We recommend it be specified in accordance with Section 305 of *Federal Highway Administration Standard Specifications for Road and Bridge Construction* FP-14. If geosynthetics are utilized, we recommend they be placed and constructed in accordance with the manufacturer's recommendations.

D. Construction

D.1. Earthwork

It is our opinion the existing pavement and soils encountered by the borings can be performed with conventional earthwork construction equipment. As previously indicated, however, consideration can be given to using low ground-pressure tracked equipment for the earthwork on the project when considering the moisture sensitive fine-grained subgrade soils prevalent along the alignment. The smaller tracked equipment will reduce the extent of creating unstable subgrades during construction. If excavations are needed for components of the project, it is our opinion all soils should be considered Type C soils under Department of Labor Occupational Safety and Health Administration (OSHA) guidelines. All earthwork and construction should be performed in accordance with OSHA guidelines.

D.2. Observations

We recommend pavement subgrades and the reclamation process be observed by a geotechnical engineer or an engineering technician working under the direction of a geotechnical engineer to see if the existing pavement and subgrade soils are similar to those encountered by the borings. The removal of unsuitable soils and materials should also be observed.

D.3. Moisture Conditioning

The majority of the soils encountered along the project will be at or slightly below optimum moisture content. We anticipate it will be necessary to add moisture to these soils to achieve a moisture content near or slightly above optimum for recompaction. As previously mentioned, the subgrade Borings ST-4, ST-7, and ST-9A were found to be over optimum moisture content. It will likely be necessary to allow these soils to dry out to achieve a moisture content near optimum for recompaction.

It should also be anticipated that imported fill and backfill materials will be below optimum moisture content and additional moisture will be necessary to achieve a moisture content near or slightly above optimum.

D.4. Testing

We recommend density testing of subgrade, base course, reclaimed base course, and FDR with CTB be performed during construction. Samples of proposed materials should be submitted to our testing laboratory at least three days prior to placement on the site for evaluation and determination of their optimum moisture contents and maximum dry densities.

We recommend density testing of the asphaltic concrete pavement (cores and nuclear density gauge). The maximum density of the asphaltic concrete mix should be determined by American Society for Testing and Materials (ASTM) D 2041 (Rice). We also recommend Marshall tests of the asphalt mix to evaluate strength and air voids.

D.5. Cold Weather Construction

If site grading and construction is anticipated during cold weather, we recommend good winter construction practices be observed. All snow and ice should be removed from cut and fill areas prior to additional grading. No fill should be placed on soils that have frozen or contain frozen material. No frozen soils should be used as fill.

If the earthwork and site preparation is planned during the winter and early spring, additional work will be required due to the inherent wetter ground conditions, increased rain or snow fall, frozen ground, lack of drying weather and shorter work days. This additional work often includes, but is not limited to, subexcavation of unsuitable material, imported suitable fill, geosynthetics, ground heaters, waste of frozen or wet material and higher testing and observation costs. The additional work can delay the contractor's schedule and result in substantial additional costs that are often passed onto the owner.

E. Procedures

E.1. Drilling and Sampling

The penetration test borings were performed on November 8 and 9, 2017, with a truck-mounted core and auger drill. Sampling for the borings was conducted in accordance with ASTM D 1586, "Penetration Test and Split-Barrel Sampling of Soils." Using this method, we advanced the borehole with hollow-stem auger to the desired test depth. Then a 140-pound hammer falling 30 inches drove a standard, 2-inch OD, split-barrel sampler a total penetration of 1 1/2 feet below the tip of the hollow-stem auger. The blows for the last foot of penetration were recorded and are an index of soil strength characteristics.

In Boring ST-10, one 3-inch diameter thin-walled tube sample was taken in alluvial soils in general accordance with ASTM D 1587, "Thin-walled Tube Sampling of Soils." The tubes were slowly pushed

into undisturbed soils below the hollow-stem auger. After they were withdrawn from the boreholes, the ends of the tubes were sealed and the tubes were carefully transported to our laboratory.

Boring ST-10 encountered sandstone bedrock. When the sampler could not be driven 6 inches with 50 blows of the hammer, the distance the sampler was advanced with 50 blows was recorded. When this situation occurred during the first 6 inches of the drive, it was noted as occurring within the "set."

E.2. Soil Classification

The field geotechnical engineer visually and manually classified the soils encountered in the borings in accordance with ASTM D 2488, "Standard Practice for Description and Identification of Soils (Visual-Manual Procedures)." A summary of the ASTM classification system is attached. All samples were then returned to our laboratory. Representative samples will remain in our office for a period of 60 days to be available for your examination.

E.3. Groundwater Observations

About 10 minutes after taking the final sample in the bottom of a boring, the driller probed through the hollow-stem auger to check for the presence of groundwater. Immediately after withdrawal of the auger, the driller again probed the depth to water or cave-in. The boring was then backfilled.

F. General Recommendations

F.1. Basis of Recommendations

The analyses and recommendations submitted in this report are based upon the data obtained from the soil borings performed at the locations indicated on the attached sketch. Often, variations occur between these borings, the nature and extent of which do not become evident until additional exploration or construction is conducted. A reevaluation of the recommendations in this report should be made after performing on-site observations during construction to note the characteristics of any variations. The variations may result in additional foundation costs, and it is suggested a contingency be provided for this purpose.

It is recommended we be retained to perform the observation and testing program for the site preparation phase of this project. This will allow correlation of the soil conditions encountered during construction to the soil borings, and will provide continuity of professional responsibility.

F.2. Review of Design

This report is based on the design of the proposed structure as related to us for preparation of this report. It is recommended we be retained to review the geotechnical aspects of the designs and specifications.

With the review, we will evaluate whether any changes in design have affected the validity of the recommendations, and whether our recommendations have been correctly interpreted and implemented in the design and specifications.

F.3. Groundwater Fluctuations

We made water level observations in the borings at the times and under the conditions stated on the boring logs. These data were interpreted in the text of this report. The period of observation was relatively short, and fluctuation in the groundwater level may occur due to rainfall, flooding, irrigation, spring thaw, drainage, and other seasonal and annual factors not evident at the time the observations were made. Design drawings and specifications and construction planning should recognize the possibility of fluctuations.

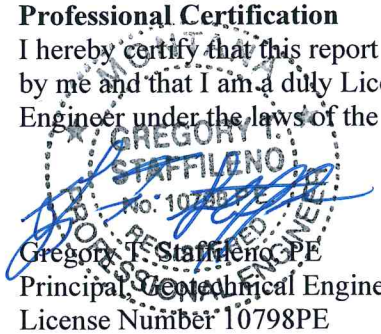
F.4. Use of Report

This report is for the exclusive use of Robert Peccia & Associates to use to design the proposed roadway pavement improvements and prepare construction documents. In the absence of our written approval, we make no representation and assume no responsibility to other parties regarding this report. The data, analyses, and recommendations may not be appropriate for other projects or purposes. We recommend parties contemplating other projects or purposes contact us.

F.5. Level of Care

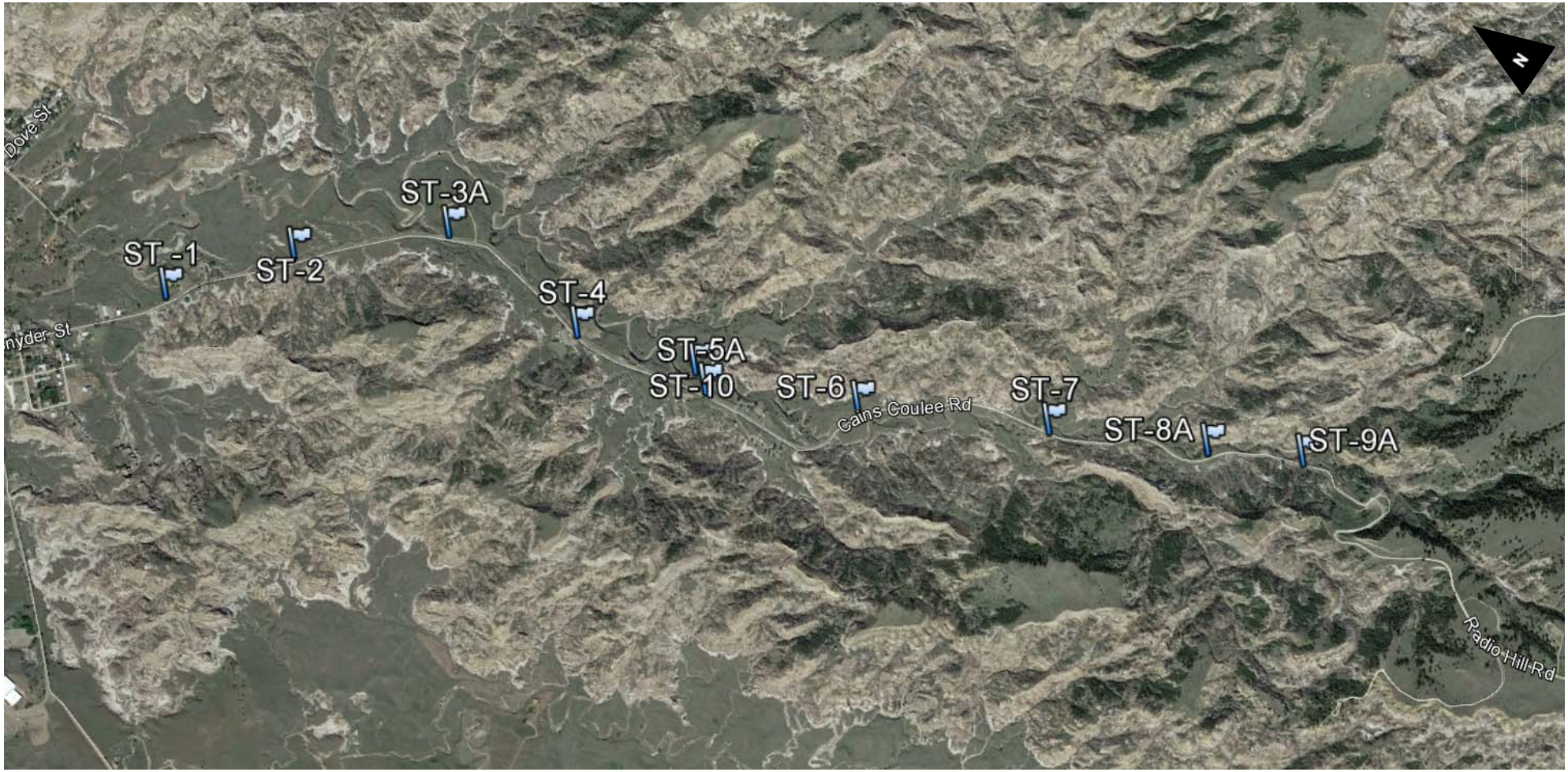
Services performed by SK Geotechnical Corporation personnel for this project have been conducted with that level of care and skill ordinarily exercised by members of the profession currently practicing in this area under similar budget and time restraints. No warranty, expressed or implied, is made.

Professional Certification
I hereby certify that this report was prepared by me and that I am a duly Licensed Professional Engineer under the laws of the State of Montana.



Gregory T. Staffileno, PE
Principal, Geotechnical Engineer
License Number 10798PE
January 29, 2018

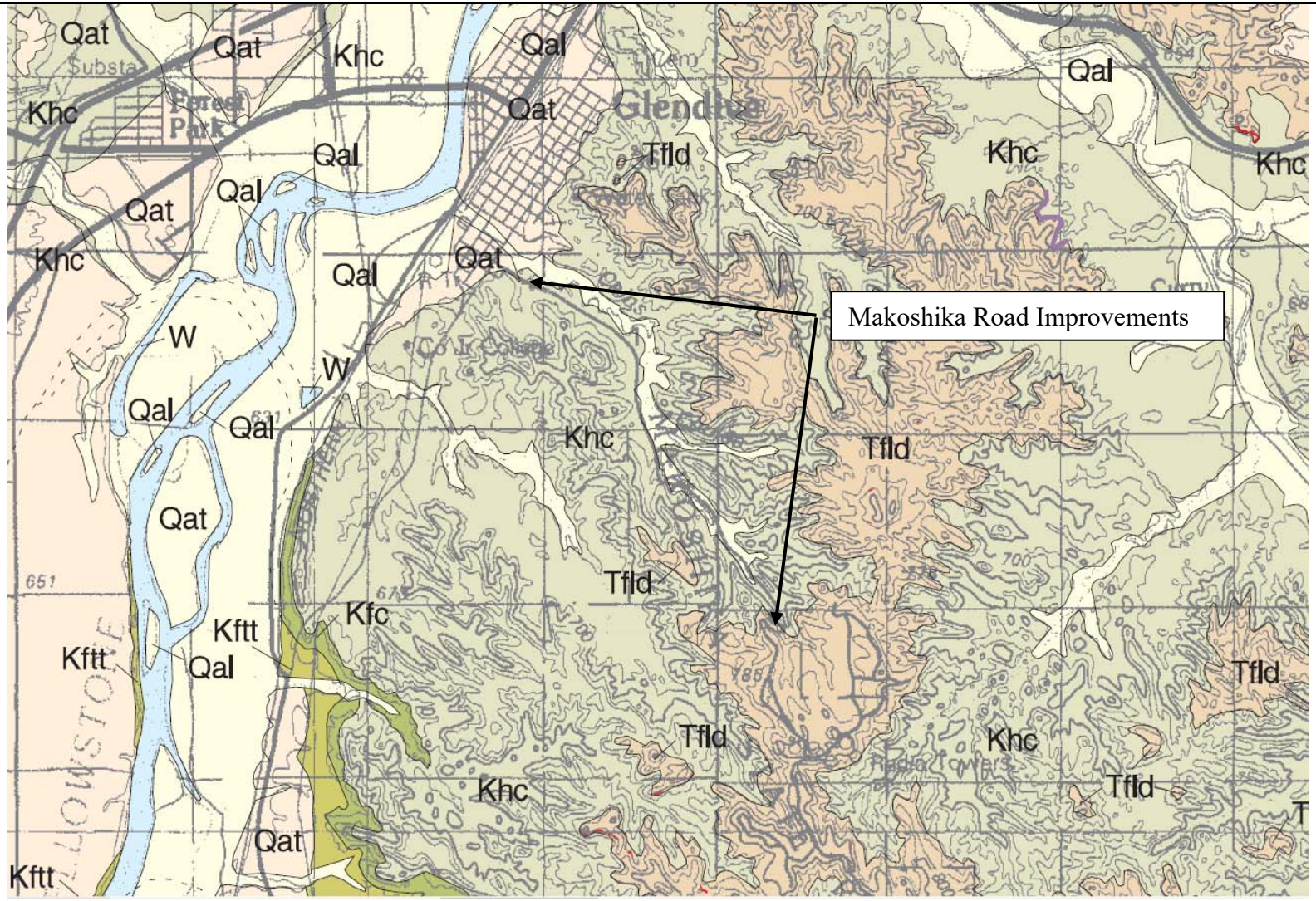
Appendix 1



SK GEOTECHNICAL

BORING LOCATION SKETCH
Makoshika State Park Road Improvements
Glendive, Montana

Drawn by:	Google	Date	?
Project:	17-3612G		
Scale:	None	FIGURE	
Sheet	of		



Geologic Map of the Glendive 30' x 60' Quadrangle
Eastern Montana and Adjacent North Dakota

S.M. Vuke and R.B. Colton

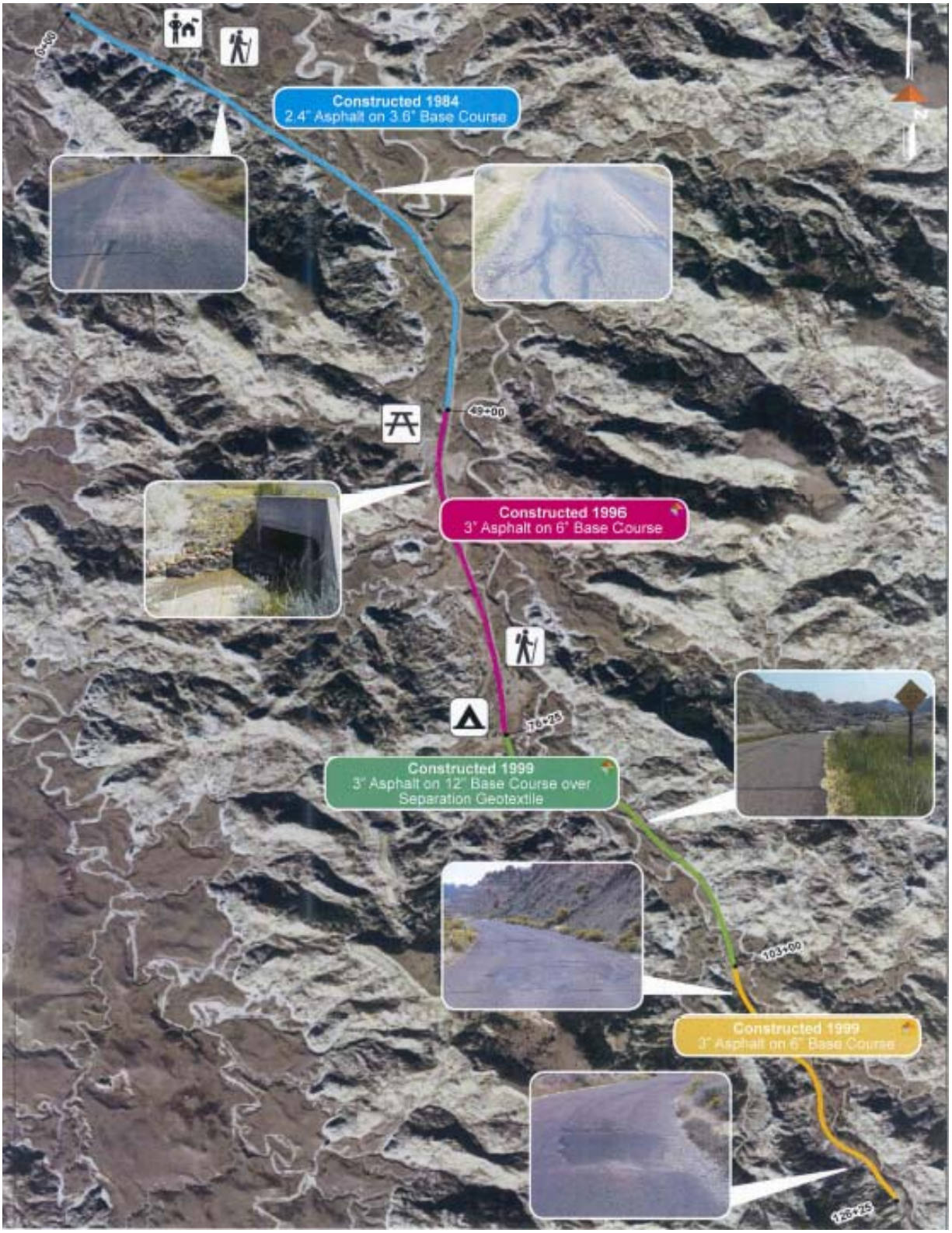
1998

Qat	Alluvium of alluvial terrace deposit	Tfld	Ludlow Member of Fort Union Formation
Khc	Hell Creek Formation		

SK GEOTECHNICAL

GEOLOGIC MAP
Makoshika State Park Road Improvements
Glendive, Montana

Drawn by:	USGS	Date	1998
Project:	17-3612G		
Scale:	None	FIGURE	
Sheet	of		



SK GEOTECHNICAL	**PAVEMENT HISTORY SKETCH** Makoshika State Park Road Improvements Glendive, Montana	Drawn by: DOWL	Date 2017
		Project: 17-3612G	
		Scale: None	FIGURE
		Sheet of	

Descriptive Terminology

Standard D 2487
Classification of Soils for Engineering Purposes
(Unified Soil Classification System)

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A]				Soil Classification	
				Group Symbol	Group Name [B]
Coarse-Grained Soils More than 50% retained on No. 200 sieve	Gravels More than 50% of coarse fraction retained on No. 4 sieve	Clean Gravels Less than 5% fines [C]	$C_U \geq 4$ and $1 \leq C_C \leq 3$ [E]	GW	Well graded gravel [F]
			$C_U < 4$ and/or $1 > C_C > 3$ [E]	GP	Poorly graded gravel [F]
		Gravels with Fines More than 12% fines [C]	Fines classify as ML or MH	GM	Silty gravel [F, G, H]
			Fines classify as CL or CH	GC	Clayey gravel [F, G, H]
	Sands 50% or more of coarse fraction passes No. 4 sieve	Clean Sands Less than 5% fines [D]	$C_U \geq 6$ and $1 \leq C_C \leq 3$ [E]	SW	Well graded sand [I]
			$C_U < 6$ and/or $1 > C_C > 3$ [E]	SP	Poorly graded sand [I]
		Sands with Fines More than 12% fines [D]	Fines classify as ML or MH	SM	Silty sand [G, H, I]
			Fines classify as CL or CH	SC	Clayey sand [G, H, I]
Fine-Grained Soils 50% or more passes the No. 200 sieve	Silts and Clays Liquid Limit less than 50	Inorganic	PI > 7 and plots on or above "A" line [J]	CL	Lean clay [K, L, M]
			PI < 4 or plots below "A" line [J]	ML	Silt [K, L, M]
		Organic	Liquid limit – oven dried / Liquid limit – not dried < 0.75	OL	Organic clay [K, L, M, N] Organic silt [K, L, M, O]
	Silts and Clays Liquid limit 50 or more	Inorganic	PI plots on or above "A" line	CH	Fat clay [K, L, M]
			PI plots below "A" line	MH	Elastic silt [K, L, M]
		Organic	Liquid limit – oven dried / Liquid limit – not dried < 0.75	OH	Organic clay [K, L, M, P] Organic silt [K, L, M, Q]
Highly Organic Soils		Primarily organic matter, dark in color, and organic odor		PT	Peat

[A] Based on the material passing the 3" (75 mm) sieve.

[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

[C] Gravels with 5 to 12% fines require dual symbols
GW-GM well-graded gravel with silt
GW-GC well-graded gravel with clay
GP-GM poorly graded gravel with silt
GP-GC poorly graded gravel with clay

[D] Sands with 5 to 12% fines require dual symbols.
SW-SC well-graded sand with clay
SP-SM poorly graded sand with silt
SP-SC poorly graded sand with clay

[E] $C_U = D_{50} / D_{10}$
$C_C = (D_{30})^2 / (D_{10} \times D_{50})$

[F] If soil contains ≥ 15% sand, add "with sand" to group name.
If fines classify as CL-ML, use dual symbol GC-GM or SC-SM.

[G]

[H] If fines are organic, add "with organic fines" to group name.

[I] If soil contains ≥ 15% gravel, add "with gravel" to group name.

[J] If Atterberg limits plot in hatched area, soil is a CL-ML, silty clay.

[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel", whichever is predominant.

[L] If soil contains ≥ 30% plus No. 200 predominantly sand, add "sandy" to group name.

[M] If soil contains ≥ 30% plus No. 200 predominantly gravel, add "gravelly" to group name.

[N] PI ≥ 4 and plots on or above "A" line.

[O] PI < 4 or plots below "A" line.

[P] PI plots on or above "A" line.

[Q] PI plots below "A" line.

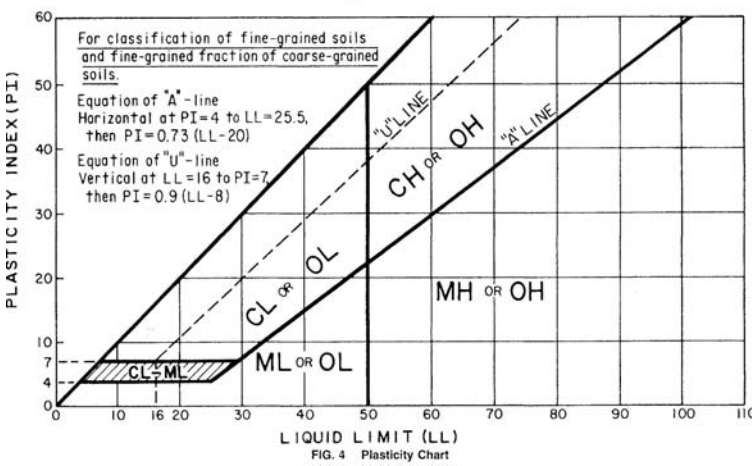


FIG. 4 Plasticity Chart

Laboratory Tests

DD	Dry density, pcf	OC	Organic content, %
WD	Wet density, pcf	P_{200}	% passing 200 sieve
LL	Liquid limit	PL	Plastic limit
PI	Plasticity index	MC	Natural moisture content, %
qu	Unconfined compressive strength, psf		
qp	Pocket penetrometer strength, tsf		

Particle Size Identification

Boulders	over 12"
Cobbles	3" to 12"
Gravel	
coarse	3/4" to 3"
fine	No. 4 to 3/4"
Sand	
coarse	No. 4 to No. 10
medium	No. 10 to No. 40
fine	No. 40 to No. 200
Silt	No. 200 to .005 mm
Clay	less than .005 mm

Relative Density of Cohesionless Soils

very loose	0 to 4 BPF
loose	5 to 10 BPF
medium dense	11 to 30 BPF
dense	31 to 50 BPF
very dense	over 50 BPF

Consistency of Cohesive Soils

very soft	0 to 1 BPF
soft	2 to 3 BPF
rather soft	4 to 5 BPF
medium	6 to 8 BPF
rather stiff	9 to 12 BPF
stiff	13 to 16 BPF
very stiff	17 to 30 BPF
hard	over 30 BPF

Moisture Content (MC) Description

rather dry	MC less than 5%, absence of moisture, dusty
moist	MC below optimum, but no visible water
wet	Soil is over optimum MC
waterbearing	Granular or low plasticity soil with free water, typically near or below groundwater table
very wet	Cohesive soil, typically near or below groundwater table

Drilling Notes

Standard penetration test borings were advanced by 3¼" or 4¼" ID hollow-stem augers, unless noted otherwise. Standard penetration test borings are designated by the prefix "ST" (split tube). Hand auger borings were advanced manually with a 2 to 3" diameter auger to the depths indicated. Hand auger borings are indicated by the prefix "HA."

Sampling. All samples were taken with the standard 2" OD split-tube sampler, except where noted. TW indicates thin-walled tube sample. CS indicates California tube sample.

BPF. Numbers indicate blows per foot recorded in standard penetration test, also known as "N" value. The sampler was set 6" into undisturbed soil below the hollow-stem auger. Driving resistances were then counted for second and third 6" increments and added to get BPF. Where they differed significantly, they were separated by backslash (/). In very dense/hard strata, the depth driven in 50 blows is indicated.

WH. WH indicates the sampler penetrated soil under weight of hammer and rods alone; driving not required.

Note. All tests were run in general accordance with applicable ASTM standards.

Bedrock Descriptors

Order of Descriptors
Bedrock Type
Color
Grain Size (if applicable)
Plasticity
Stratification/Foliation (as applicable)
Moisture
Rock Field Hardness

Example Rock Log
SANDSTONE, gray, fine-grained, thickly bedded, slightly weathered, hard field hardness.

Color
Munsell Color Chart

Grain Size
Coarse-grained ..... Individual grains can be easily distinguished by eye
Fine-grained ..... Individual grains can be distinguished with difficulty

Plasticity
Nonplastic ..... PI < 4 ..... will not ball together
Slightly plastic..... 4 ≤ PI ≤ 7 ..... somewhat balls together, cannot roll thread to 1/8"
Low plasticity..... PI > 7, LL < 35 ..... roll thread to 1/8"
Medium plasticity ..... PI > 7, 35 ≤ LL < 50 ..... roll thread to 1/8", 1" ribbon
High plasticity ..... PI > 7, LL ≥ 50 ..... roll threat to 1/8", 1 1/2" ribbon or larger

Stratum Thickness
Thickly bedded.....3'-10'
Medium bedded.....1'-3'
Thinly bedded .....2"-12"
Very thinly bedded.....< 2"

Moisture
Dry ..... oven dried
Rather dry..... 0%-5%, no apparent moisture, dusty
Moist ..... under optimum moisture content, visible moisture, but no free water
Wet..... over optimum moisture content, visible free water, usually also waterbearing
Waterbearing..... below water table, produces free water

Rock Field Hardness

Very soft	Can be carved with knife; can be excavated readily with point of rock hammer; can be scratched readily by fingernail
Soft	Can be grooved or gouged readily by knife or point of rock hammer; can be excavated in fragments from chips to several inches in size by moderate blows of the point of a rock hammer
Medium	Can be grooved or gouged 0.05" deep by firm pressure of knife or rock hammer point; can be excavated in small chips to pieces about 1" maximum size by hard blows of the point of a rock hammer
Moderately hard	Can be scratched with a knife or pick; gouges or grooves to 0.25" can be excavated by hard blow of rock hammer; hand specimen can be detached by moderate blows
Hard	Can be scratched with a knife or sharp pick only with difficulty; hard hammer blows required to detach hand specimen
Very hard	Cannot be scratched with a knife or sharp rock hammer point; breaking of hand specimens requires several hard blows of a rock hammer

SK GEOTECHNICAL
2511 Holman Avenue
P. O. Box 80190
Billings, MT 59108-0190
Phone: 406.652.3930
Fax: 406.652.3944

LOG OF BORING

PROJECT: 17-3612G
PAVEMENT EVALUATION
Makoshika State Park Road Improvements
Glendive, Montana

BORING: **ST-1**

LOCATION:
See Boring Location Sketch

DRILLED BY: C. Larsen | METHOD: 3 1/4" HSA, Automatic | DATE: 11/8/17 | SCALE: 1" = 1'

Elev.	Depth	Symbol	Description of Materials	BPF	WL	MC (%)	Remarks
	0.0		0" to 4¼" Asphalt Pavement.				Frozen to 1'.
	0.4		4¼" to 7½" Base Course (¾" Minus).				Good Quality Base
	0.6		7½" to 11½" Subbase Course (3" Minus).				
	1.0	SM	SILTY SAND, fine-grained, trace salts, light olive brown, rather dry, medium dense to dense. (Alluvium)	30		5.4	Bulk Bag 1'-4' LL=NP,PL=NP,PI=NP P_{200}=30% MDD=112.0 pcf OMC=13.0% CBR=7.3
				14		5.3	
				12		4.4	
	5.5		END OF BORING Water not observed with 4' of hollow-stem auger in the ground. Water not observed to dry cave-in depth of 2.2' immediately after withdrawal of auger.				

BORING BPF WL MC 3612-PVT.GPJ LAGNNN06.GDT 1/8/18

SK GEOTECHNICAL
2511 Holman Avenue
P. O. Box 80190
Billings, MT 59108-0190
Phone: 406.652.3930
Fax: 406.652.3944

LOG OF BORING

PROJECT: 17-3612G
PAVEMENT EVALUATION
Makoshika State Park Road Improvements
Glendive, Montana

BORING: **ST-2**

LOCATION:
See Boring Location Sketch

DRILLED BY: C. Larsen | METHOD: 3 1/4" HSA, Automatic | DATE: 11/8/17 | SCALE: 1" = 1'

Elev.	Depth	Symbol	Description of Materials	BPF	WL	MC (%)	Remarks
	0.0		0" to 3" Asphalt Pavement.				Frozen to 1'.
	0.3		3" to 6¼" Base Course (1" Minus).				
	0.5	SM	SILTY SAND, very fine-grained, trace humus, olive brown, moist, loose. (Alluvium)	10		9.4	Fair Quality Base
	3.0	CL	LEAN CLAY with SAND, medium plasticity, olive brown, wet, medium. (Alluvium)	3/4		16.0	
	4.0	SM	SILTY SAND, fine-grained, yellowish brown, wet, medium dense. (Decomposed Sandstone)	17		13.8	
	5.5		END OF BORING Water not observed with 4' of hollow-stem auger in the ground. Water not observed to dry cave-in depth of 2.3' immediately after withdrawal of auger.				

BORING BPF WL MC 3612-PVT.GPJ LAGNNN06.GDT 1/8/18

SK GEOTECHNICAL
2511 Holman Avenue
P. O. Box 80190
Billings, MT 59108-0190
Phone: 406.652.3930
Fax: 406.652.3944

LOG OF BORING

PROJECT: 17-3612G
PAVEMENT EVALUATION
Makoshika State Park Road Improvements
Glendive, Montana

BORING: **ST-3A**

LOCATION:
Moved into W. Bound Lane Due to Utilities, See Boring Location Sketch

DRILLED BY: C. Larsen | METHOD: 3 1/4" HSA, Automatic | DATE: 11/8/17 | SCALE: 1" = 1'

Elev.	Depth	Symbol	Description of Materials	BPF	WL	MC (%)	Remarks
	0.0		0" to 3¼" Asphalt Pavement.				Frozen to 1'.
	0.3		3¼" to 5¾" Base Course, sandy (¾" Minus).				
	0.5	CL	SANDY LEAN CLAY, low plasticity, trace gravel, olive brown, moist, stiff. (Alluvium)				Fair Quality Base
							Bulk Bag 1'-3½'
	1.5			7/6		12.4	
		SM	SILTY SAND, fine-grained, trace lenses of lean clay and scoria, yellowish brown, moist, loose. (Alluvium)	5		12.6	
	4.5						
		SM	SILTY SAND with GRAVEL, fine- to coarse-grained, some scoria, trace humus, olive brown and reddish gray, rather dry, medium dense. (Alluvium)	21		9.8	
	5.5		END OF BORING				
			Water not observed with 4' of hollow-stem auger in the ground.				
			Water not observed to dry cave-in depth of 2.1' immediately after withdrawal of auger.				

BORING BPF WL MC 3612-PVT.GPJ LAGNNN06.GDT 1/8/18

SK GEOTECHNICAL
2511 Holman Avenue
P. O. Box 80190
Billings, MT 59108-0190
Phone: 406.652.3930
Fax: 406.652.3944

LOG OF BORING

PROJECT: 17-3612G
PAVEMENT EVALUATION
Makoshika State Park Road Improvements
Glendive, Montana

BORING: **ST-4**

LOCATION:
See Boring Location Sketch

DRILLED BY: C. Larsen | METHOD: 3 1/4" HSA, Automatic | DATE: 11/8/17 | SCALE: 1" = 1'

Elev.	Depth	Symbol	Description of Materials	BPF	WL	MC (%)	Remarks
	0.0						
	0.2		0" to 2½" Asphalt Pavement.				Frozen to 1'.
			2½" to 8½" Base Course (¾" Minus).				
	0.7						Good Quality Base
		CL	SANDY LEAN CLAY, low plasticity, trace gravel, olive brown, moist to wet, rather stiff to medium. (Alluvium)	11		19.7	Bulk Bag 1'-4' LL=27, PL=15, PI=12 P_{200}=59%
			-trace lenses of silty sand below 2'	7		17.7	
	3.5	SM	SILTY SAND, fine-grained, trace gravel and scoria, brown, moist to wet, very loose to loose. (Alluvium)	2/6		12.1	
	5.5		END OF BORING				
			Water not observed with 4' of hollow-stem auger in the ground.				
			Water not observed to dry cave-in depth of 2.4' immediately after withdrawal of auger.				

BORING BPF WL MC 3612-PVT.GPJ LAGNNN06.GDT 1/8/18

SK GEOTECHNICAL
2511 Holman Avenue
P. O. Box 80190
Billings, MT 59108-0190
Phone: 406.652.3930
Fax: 406.652.3944

LOG OF BORING

PROJECT: 17-3612G
PAVEMENT EVALUATION
Makoshika State Park Road Improvements
Glendive, Montana

BORING: **ST-5A**

LOCATION:
Moved into W. Bound Lane Due to Utilities, See Boring Location Sketch

DRILLED BY: C. Larsen | METHOD: 3 1/4" HSA, Automatic | DATE: 11/8/17 | SCALE: 1" = 1'

Elev.	Depth	Symbol	Description of Materials	BPF	WL	MC (%)	Remarks
	0.0		0" to 3" Asphalt Pavement.				Frozen to 1'.
	0.3		3" to 8¼" Base Course, sandy (¾" Minus).				Good Quality Base
	0.7	CL ML	SILTY CLAY with SAND, slightly plastic, grayish brown, moist, stiff. (Alluvium)				
	1.5	SM	SILTY SAND, fine-grained, yellowish brown, moist to wet, loose to medium dense. (Alluvium)	8/7		10.7	
	3.0	CL ML	SILTY CLAY, slightly plastic, trace sand, olive brown, moist, medium. (Alluvium)	5/4		17.7	
	4.0	SM	SILTY SAND, fine-grained, olive brown, rather moist, loose. (Alluvium)	5		10.3	
	5.5		END OF BORING Water not observed with 4' of hollow-stem auger in the ground. Water not observed to dry cave-in depth of 2.1' immediately after withdrawal of auger.				

BORING BPF WL MC 3612-PVT.GPJ LAGNNN06.GDT 1/8/18

SK GEOTECHNICAL
2511 Holman Avenue
P. O. Box 80190
Billings, MT 59108-0190
Phone: 406.652.3930
Fax: 406.652.3944

LOG OF BORING

PROJECT: 17-3612G
PAVEMENT EVALUATION
Makoshika State Park Road Improvements
Glendive, Montana

BORING: **ST-6**

LOCATION:
See Boring Location Sketch

DRILLED BY: C. Larsen | METHOD: 3 1/4" HSA, Automatic | DATE: 11/8/17 | SCALE: 1" = 1'

Elev.	Depth	Symbol	Description of Materials	BPF	WL	MC (%)	Remarks
	0.0		0" to 3" Asphalt Pavement.				Frozen to 1'.
	0.3		3" to 13½" Base Course (¾" Minus).				Good Quality Base
	1.1		-non-woven fabric beneath base course				
		CL	LEAN CLAY with SAND, low plasticity, dark brown and brown, moist to wet, stiff to soft. (Alluvium)	16		8.2	Bulk Bag 1½'-4' LL=26, PL=17, PI=9 P_{200}=71% MDD=113.5 pcf OMC=15.0% CBR=6.9
			-trace silty sand lenses below 3'	6		14.9	
			-wet, saturated below 4'	2		25.2	
	5.5		END OF BORING				

Water not observed with 4' of hollow-stem auger in the ground.

Water not observed to dry cave-in depth of 2.2' immediately after withdrawal of auger.

BORING BPF WL MC 3612-PVT.GPJ LAGNNN06.GDT 1/8/18

SK GEOTECHNICAL
2511 Holman Avenue
P. O. Box 80190
Billings, MT 59108-0190
Phone: 406.652.3930
Fax: 406.652.3944

LOG OF BORING

PROJECT: 17-3612G
PAVEMENT EVALUATION
Makoshika State Park Road Improvements
Glendive, Montana

BORING: **ST-7**

LOCATION:
See Boring Location Sketch

DRILLED BY: C. Larsen | METHOD: 3 1/4" HSA, Automatic | DATE: 11/8/17 | SCALE: 1" = 1'

Elev.	Depth	Symbol	Description of Materials	BPF	WL	MC (%)	Remarks
	0.0						
	0.1		0" to 1" patched Asphalt Pavement.				Frozen to 1'.
	0.4		1" to 5" of FILL: Clayey Gravel with Sand, low plasticity, fine- to coarse-grained, brown, wet.				
			5" to 10" of FILL: Silty Sand with Gravel, fine- to coarse-grained, olive brown, moist.				Disrupted pavement likely due to active landslide movement above and below the roadway.
	0.8		FILL: Clayey Sand with Gravel, low plasticity, fine- to coarse-grained, brown, wet, very loose.				
	2.0			2/5		20.7	Bulk Bag 1'-4'
		CL	LEAN CLAY with SAND, medium plasticity, dark brown and gray, wet, rather stiff to very stiff. (Decomposed Shale)	20		29.2	
	4.5						
			WEATHERED SHALE, medium to high plasticity, trace FeOx staining, fissiled, moist, very soft hardness.	53		19.8	
	5.5						
			END OF BORING				
			Water not observed with 4' of hollow-stem auger in the ground.				
			Water not observed to dry cave-in depth of 2.4' immediately after withdrawal of auger.				

BORING BPF WL MC 3612-PVT.GPJ LAGNNN06.GDT 1/8/18

SK GEOTECHNICAL
2511 Holman Avenue
P. O. Box 80190
Billings, MT 59108-0190
Phone: 406.652.3930
Fax: 406.652.3944

LOG OF BORING

PROJECT: 17-3612G
PAVEMENT EVALUATION
Makoshika State Park Road Improvements
Glendive, Montana

BORING: **ST-8A**

LOCATION:
See Boring Location Sketch

DRILLED BY: C. Larsen | METHOD: 3 1/4" HSA, Automatic | DATE: 11/8/17 | SCALE: 1" = 1'

Elev.	Depth	Symbol	Description of Materials	BPF	WL	MC (%)	Remarks
	0.0		0" to 3" Asphalt Pavement.				Frozen to 1'.
	0.3		3" to 8½" Base Course (¾" Minus).				Good Quality Base
	0.7	CL	SANDY LEAN CLAY, low plasticity, trace salts, olive brown, rather dry, medium. (Alluvium)				
	1.5	SM	SILTY SAND, fine-grained, trace gravel, brown to yellowish brown, moist to rather dry, very loose to medium dense. (Decomposed Sandstone)	4/3		11.6	
				13		7.1	
				27		6.8	
	5.5		END OF BORING Water not observed with 4' of hollow-stem auger in the ground. Water not observed to dry cave-in depth of 2.0' immediately after withdrawal of auger.				

BORING BPF WL MC 3612-PVT.GPJ LAGNNN06.GDT 1/8/18

SK GEOTECHNICAL
2511 Holman Avenue
P. O. Box 80190
Billings, MT 59108-0190
Phone: 406.652.3930
Fax: 406.652.3944

LOG OF BORING

PROJECT: 17-3612G
PAVEMENT EVALUATION
Makoshika State Park Road Improvements
Glendive, Montana

BORING: **ST-9A**

LOCATION:
Moved 0.15 Miles W Off Switchbacks Due to Black Ice, E. Bound Lane, See Boring Location Sketch

DRILLED BY: C. Larsen | METHOD: 3 1/4" HSA, Automatic | DATE: 11/8/17 | SCALE: 1" = 1'

Elev.	Depth	Symbol	Description of Materials	BPF	WL	MC (%)	Remarks
	0.0						
	0.2		0" to 2½" Asphalt Pavement.				Frozen to 1'.
			2½" to 10" Base Course, trace scoria (¾" Minus).				Poor Quality Base
	0.8						
			FILL: Clayey Sand with Gravel, fine- to coarse-grained, low plasticity, brown, moist.				
	1.2						
		CH	FAT CLAY with SAND, high plasticity, trace sandstone and FeOx staining, dark olive brown, wet, medium to rather stiff. (Decomposed Shale)	8		26.3	Bulk Bag 1½'-4' LL=53, PL=17, PI=36 P_{200}=78% MDD=111.9 pcf OMC=16.2% CBR=1.0
				9		20.9	
				9		21.7	
	5.5						
			END OF BORING Water not observed with 4' of hollow-stem auger in the ground. Water not observed to dry cave-in depth of 2.5' immediately after withdrawal of auger.				

BORING BPF WL MC 3612-PVT.GPJ LAGNNN06.GDT 1/8/18

SK GEOTECHNICAL
2511 Holman Avenue
P. O. Box 80190
Billings, MT 59108-0190
Phone: 406.652.3930
Fax: 406.652.3944

LOG OF BORING

PROJECT: 17-3612G
PAVEMENT EVALUATION
Makoshika State Park Road Improvements
Glendive, Montana

BORING: **ST-10**

LOCATION:
Pedestrian Bridge, S Abutment, See Boring Location Sketch

DRILLED BY: C. Larsen | METHOD: 3 1/4" HSA, Automatic | DATE: 11/9/17 | SCALE: 1" = 4'

Elev.	Depth	Symbol	Description of Materials	BPF	WL	MC (%)	Remarks
135.7	0.0						
134.7	1.0	OL	ORGANIC CLAY, low plasticity, some roots, light brown, rather dry. (Topsoil)	3/4		26.2	Frozen to 1½'
		CL	SANDY LEAN CLAY, low plasticity, trace roots, light olive brown, rather dry, medium to rather stiff. (Alluvium)	11		8.1	Elevation Reference: Boring ST-5 in pavement near boring, assumed elev.=150.0.
132.7	3.0		SANDY SILT, fine-grained, olive brown and gray, moist, loose. (Alluvium)				
		ML		7		7.3	
				TW		14.2	See Collapse Test LL=NP,PL=NP,PI=NP
128.7	7.0		CLAYEY SAND, fine-grained, low plasticity, trace sandstone, olive brown, moist, medium dense to very dense. (Decomposed Sandstone)	20		18.4	P_{200}=56% DD=81.1 pcf
		SC		51		17.1	
				29		9.1	
121.2	14.5		SANDSTONE, fine-grained, slight to low plasticity, slightly cemented, yellowish brown, moist to waterbearing, soft to medium hardness.	18/50		11.0	
				39/50-4"		12.0	
			-gray, waterbearing below 24'	75	▽	21.3	LL=27, PL=17, PI=10 P_{200}=22%
				71		26.3	Very difficult drilling below 30'.

BORING BPF WL MC 3612-BR.GPJ LAGNNN06.GDT 1/8/18

SK GEOTECHNICAL
2511 Holman Avenue
P. O. Box 80190
Billings, MT 59108-0190
Phone: 406.652.3930
Fax: 406.652.3944

LOG OF BORING

PROJECT: 17-3612G
PAVEMENT EVALUATION
Makoshika State Park Road Improvements
Glendive, Montana

BORING: **ST-10 (cont.)**

LOCATION:
Pedestrian Bridge, S Abutment, See Boring Location Sketch

DRILLED BY: C. Larsen | METHOD: 3 1/4" HSA, Automatic | DATE: 11/9/17 | SCALE: 1" = 4'

Elev. 103.7	Depth 32.0	Symbol	Description of Materials	BPF	WL	MC (%)	Remarks
			SANDSTONE continued				
102.2	33.5		SHALE, very high plasticity, fissiled, dark gray, moist, soft hardness.	54		23.5	
98.2	37.5		SHALE, sandy, low to medium plasticity, trace humus and sandstone particles, dark gray, moist, moderately hard hardness.	32/50-5"		22.7	
96.8	38.9		END OF BORING - Auger Refusal				

Water down 24.9' with 25' of hollow-stem auger in the ground.

Water not observed to wet cave-in depth of 24' immediately after withdrawal of auger.

BORING BPF WL MC 3612-BR.GPJ LAGNNN06.GDT 1/8/18

Photo 1. Boring ST-1, Looking East

Photo 2. Boring ST-2, Looking West

Photo 3. Boring ST-3A, Other Lane, Looking East

Photo 4. Boring ST-4, Looking West

Photo 5. Boring ST-5A, Other Lane, Looking East

Photo 6. Boring ST-6, Looking East

Photo 7. Boring ST-7, Looking West

Photo 8. Boring ST-8A, Looking East

Photo 9. Boring ST-9A, Looking North

Photo 10. Boring ST-10, Looking Southeast

Photo 11. Existing Landslide near Switchbacks

Photo 12. Pavement Distress Due to Landslide Movement

Photo 13. Significant Slump near Switchbacks

Photo 14. Pavement Adjacent to Vertical Stream Bank

Photo 15. Pavement Adjacent to Vertical Stream Bank

Photo 16. Dispersive Soil Hole Near Boring ST-7

Photo 17. Dispersive Soil Hole near Project

Photo 18. Pavement Pothole and Rutting

Photo 19. Pavement Failure and Patching

Photo 20. Pavement Failure

DCP TEST DATA

File Name: 17-3612G

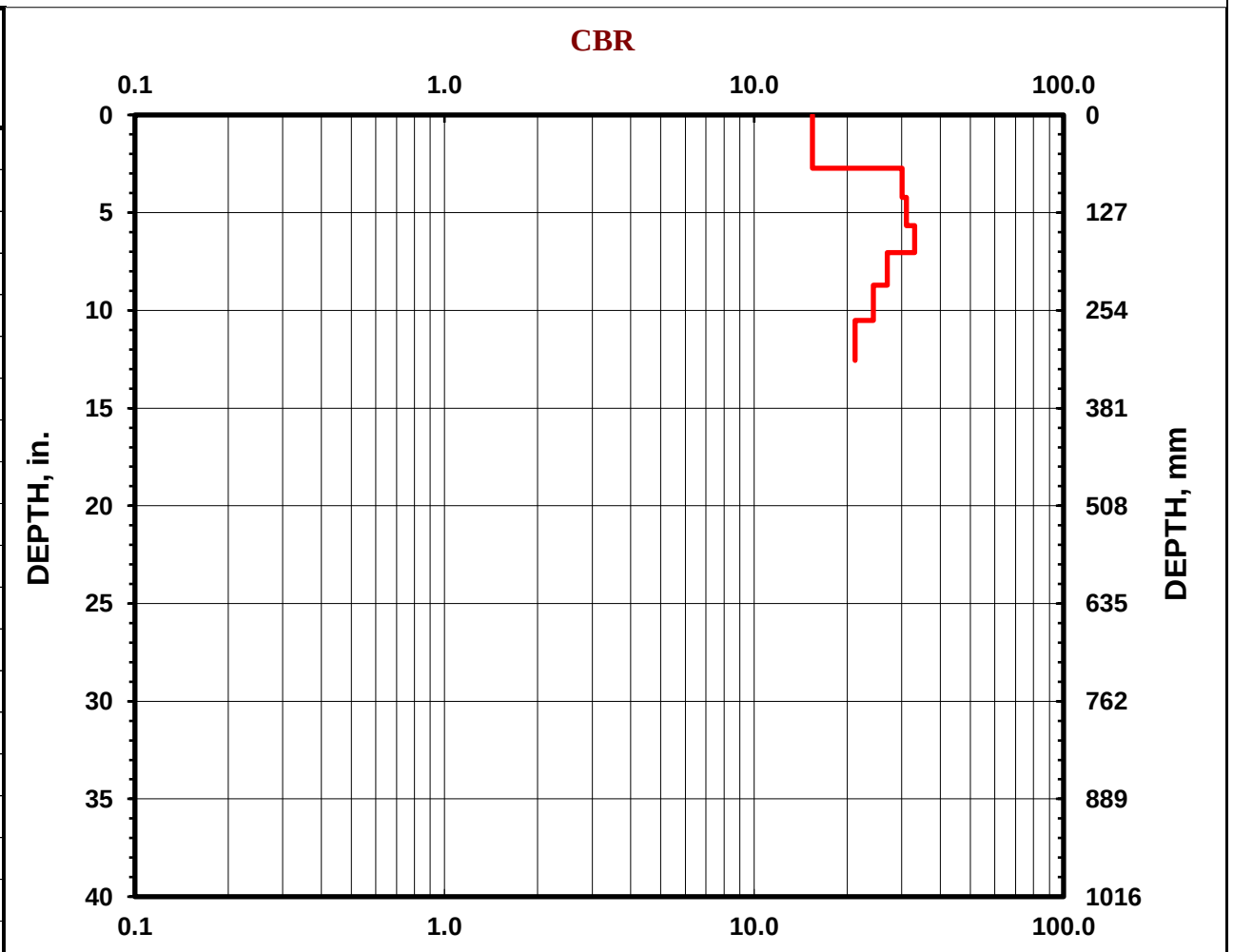
Project: *Makoshika Road Improvements* **Date:** 8-Nov-17

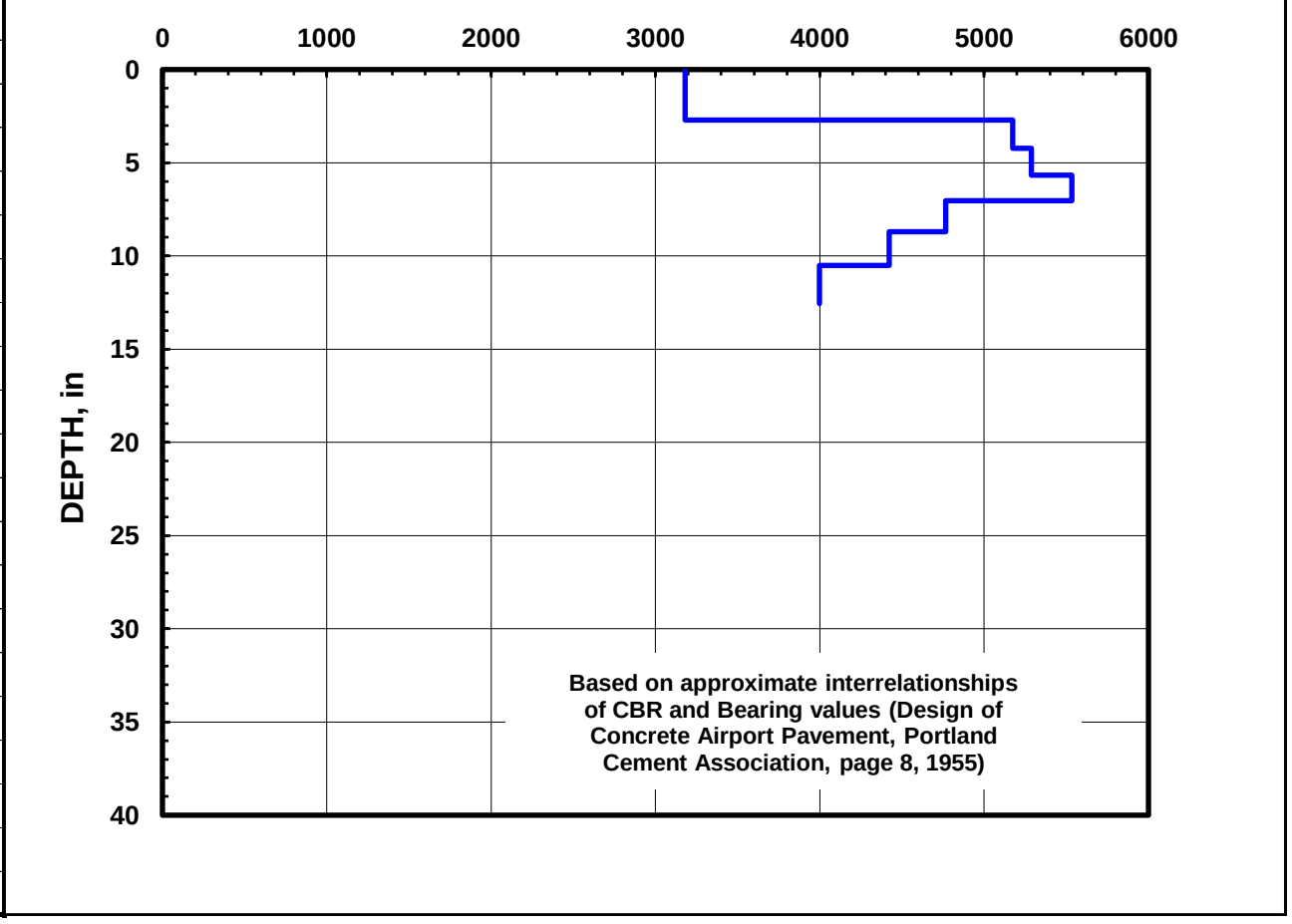
Location: Boring ST-1 **Soil Type(s):** SM

Hammer
- ○ 10.1 lbs.
- ◉ 17.6 lbs.
- ○ Both hammers used

Soil Type
- ○ CH
- ○ CL
- ◉ All other soils

No. of Blows	Accumulative Penetration (mm)	Type of Hammer
0	0	1
5	69	1
5	107	1
5	144	1
5	179	1
5	221	1
5	267	1
5	319	1





DCP TEST DATA

File Name: 17-3612G

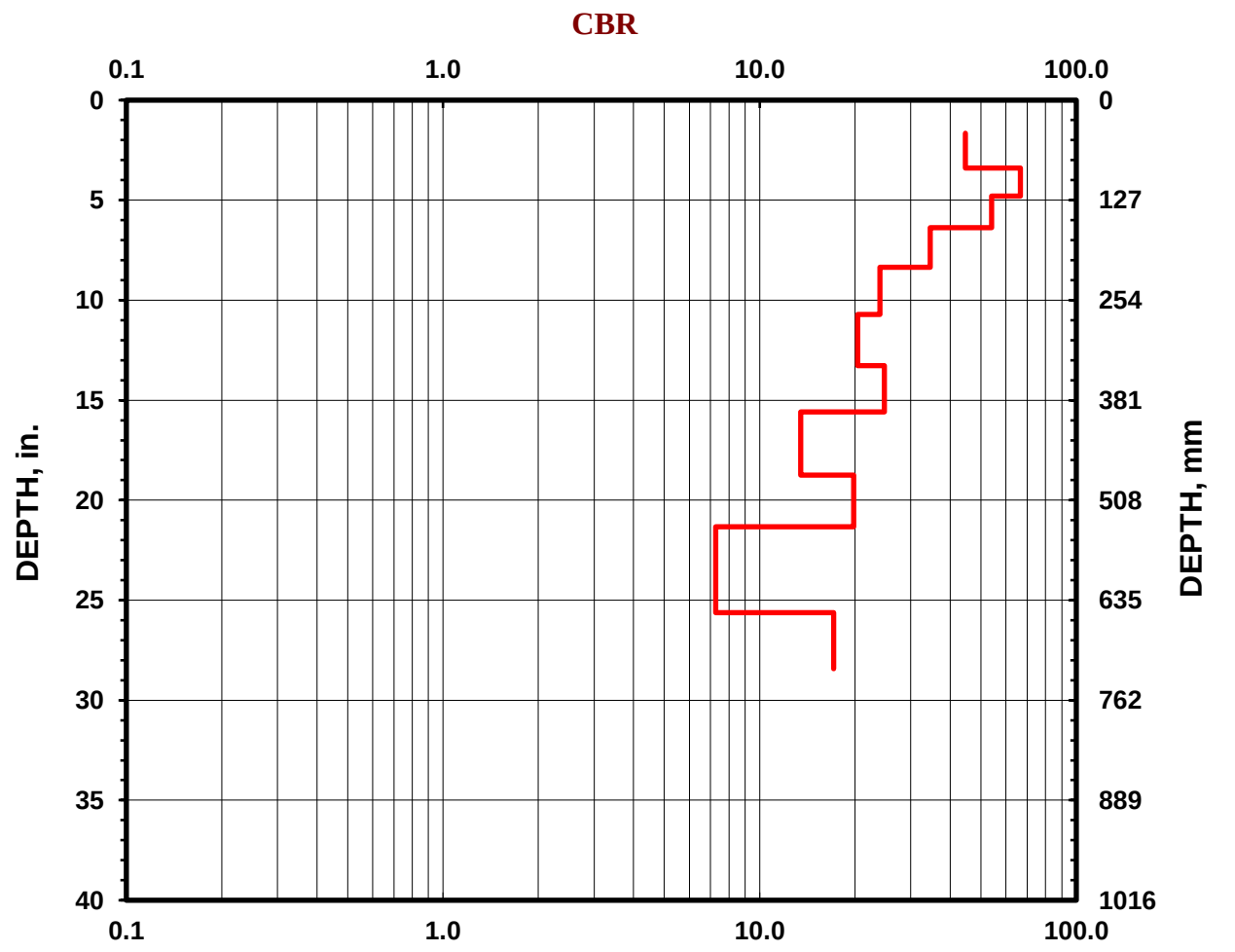
Project: *Makoshika Road Improvements* **Date:** 8-Nov-17

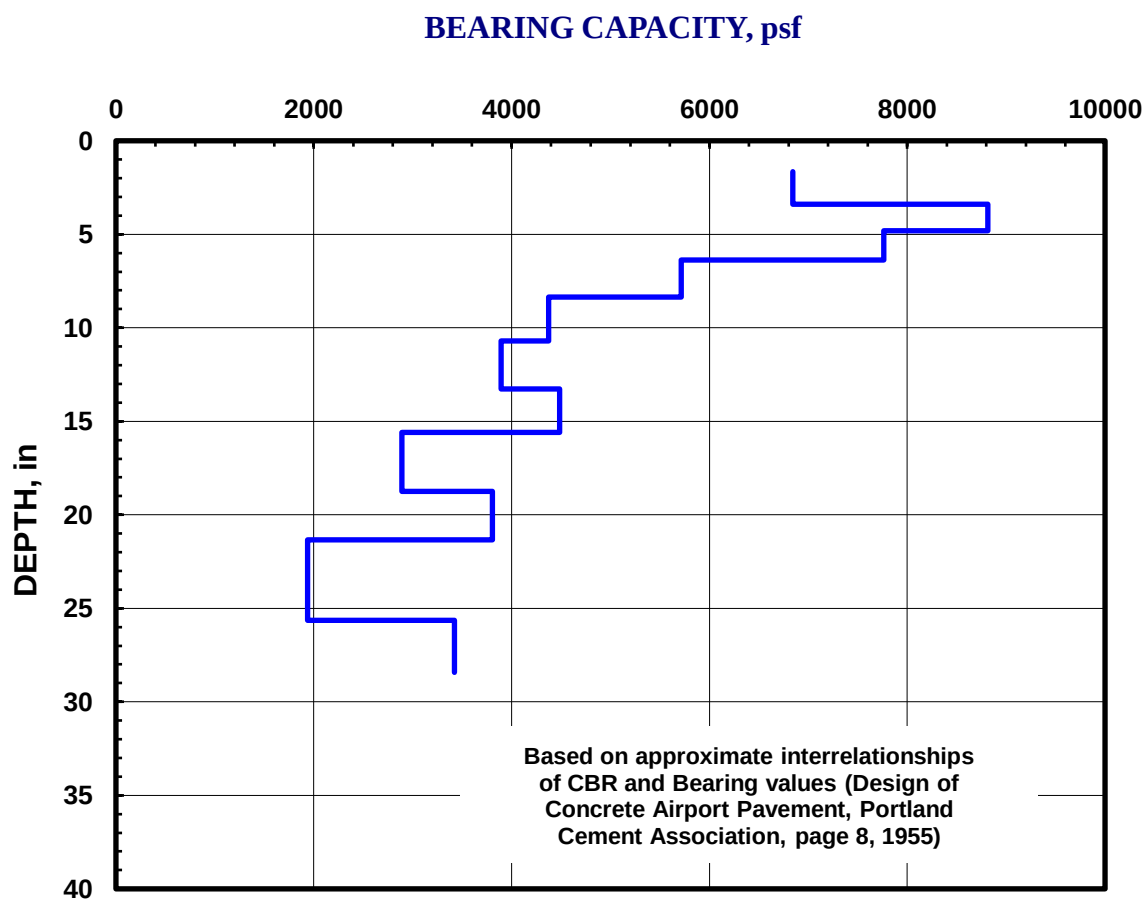
Location: Boring ST-2 **Soil Type(s):** Low plasticity Clay with CBR<10

Hammer
- ○ 10.1 lbs.
- ◉ 17.6 lbs.
- ○ Both hammers used

Soil Type
- ○ CH
- ◉ CL
- ○ All other soils

No. of Blows	Accumulative Penetration (mm)	Type of Hammer
0	42	1
5	86	1
5	122	1
5	162	1
5	212	1
5	272	1
5	337	1
5	396	1
5	476	1
5	542	1
5	651	1
5	722	1





DCP TEST DATA

File Name: 17-3612G

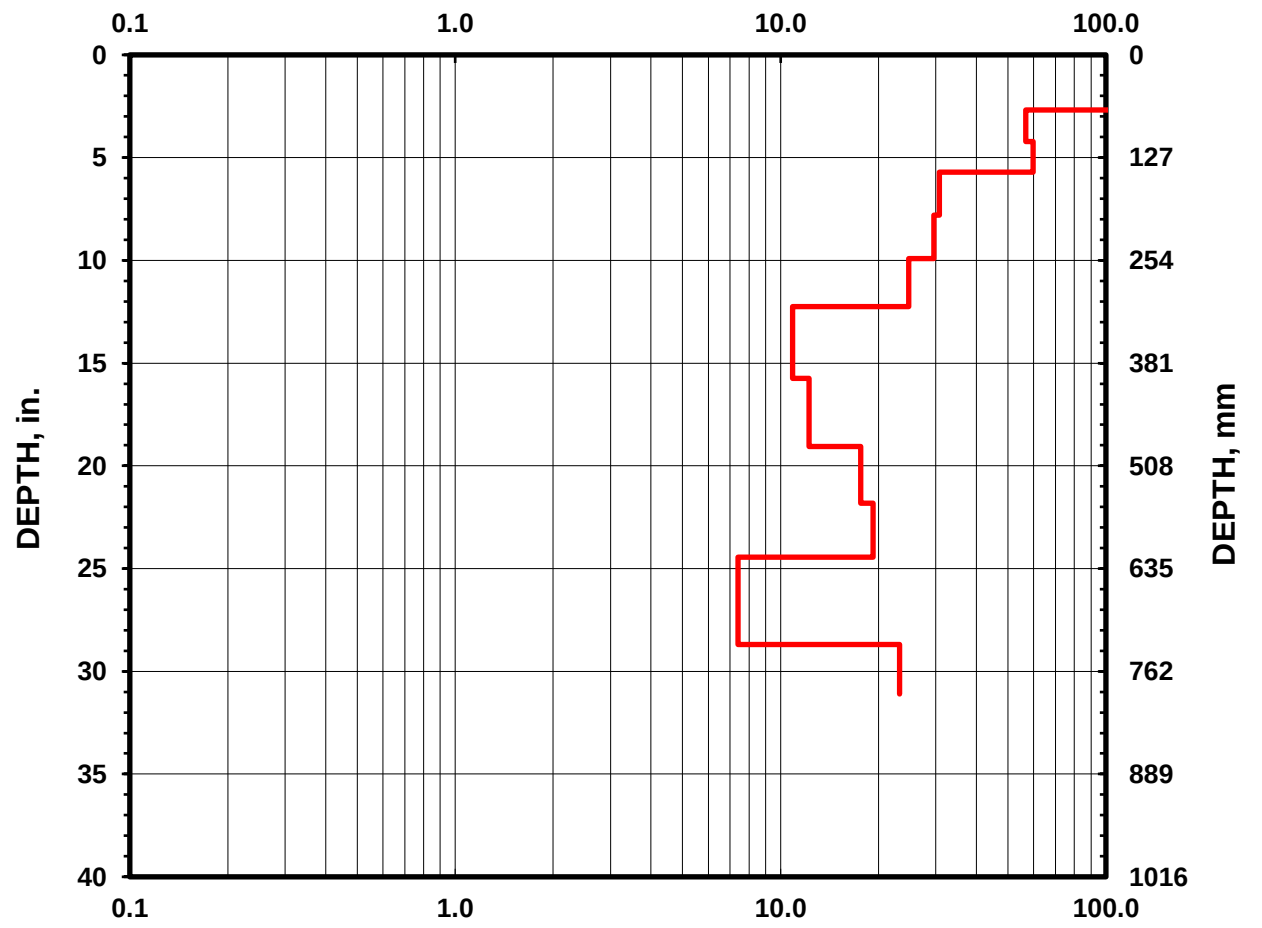
Project: *Makoshika Road Improvements* **Date:** 8-Nov-17

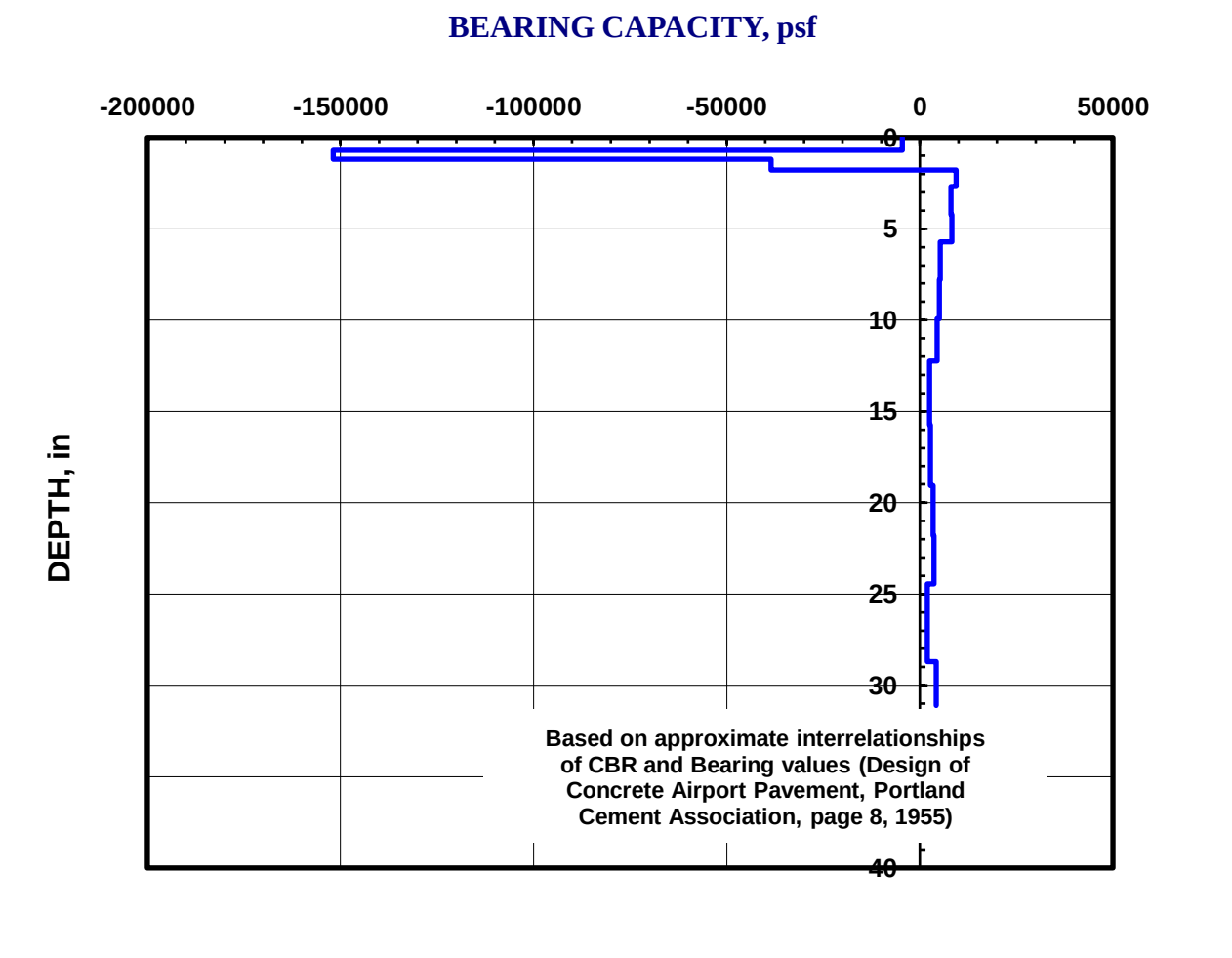
Location: Boring ST-3A **Soil Type(s):** Low plasticity Clay with CBR<10

Hammer
- ○ 10.1 lbs.
- ◉ 17.6 lbs.
- ○ Both hammers used

Soil Type
- ○ CH
- ◉ CL
- ○ All other soils

No. of Blows	Accumulative Penetration (mm)	Type of Hammer
0	0	1
5	18	1
5	30	1
5	45	1
5	68	1
5	107	1
5	145	1
5	198	1
5	252	1
5	311	1
5	400	1
5	484	1
5	554	1
5	621	1
5	729	1
5	790	1





DCP TEST DATA

File Name: 17-3612G

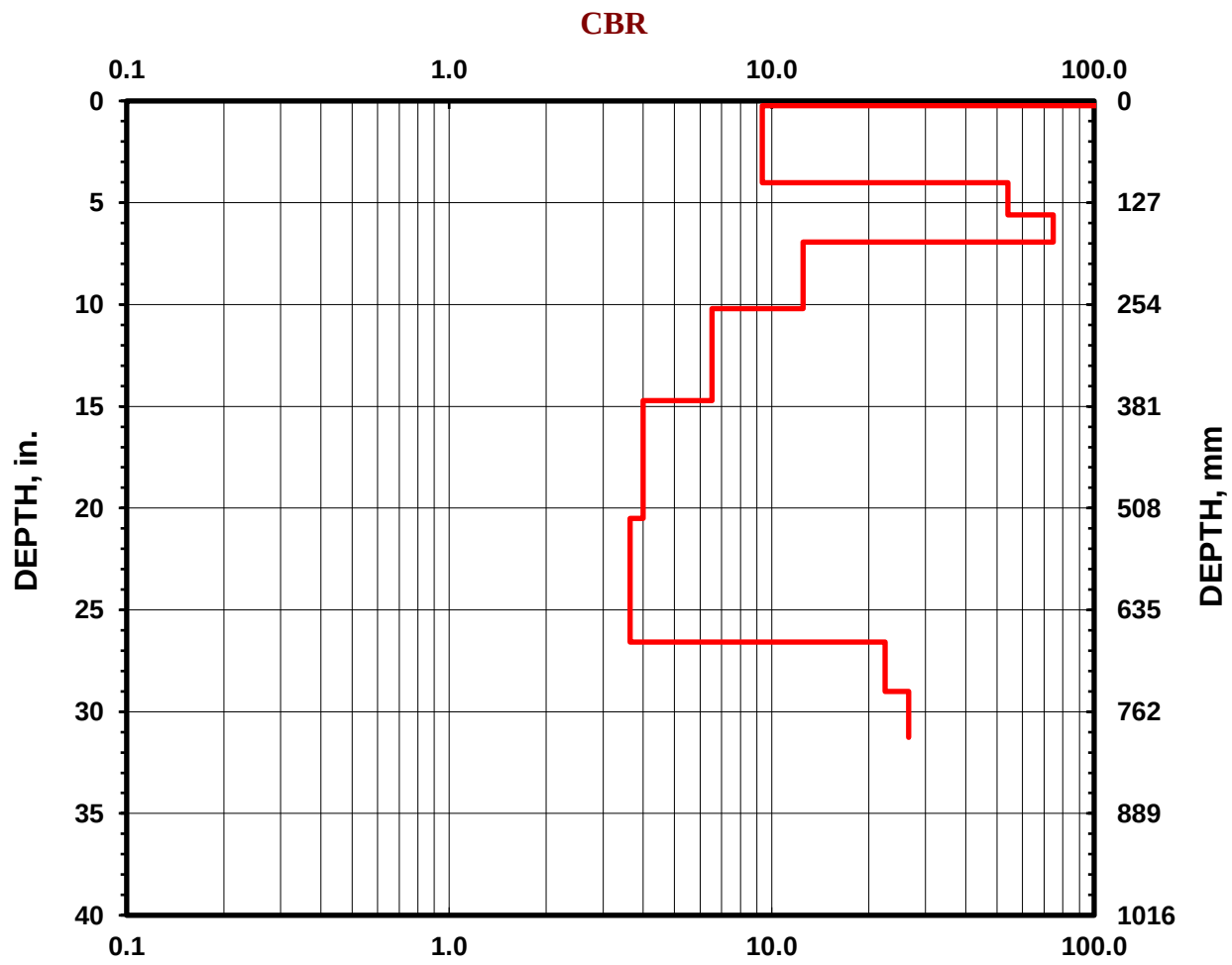
Project: *Makoshika Road Improvements* **Date:** 8-Nov-17

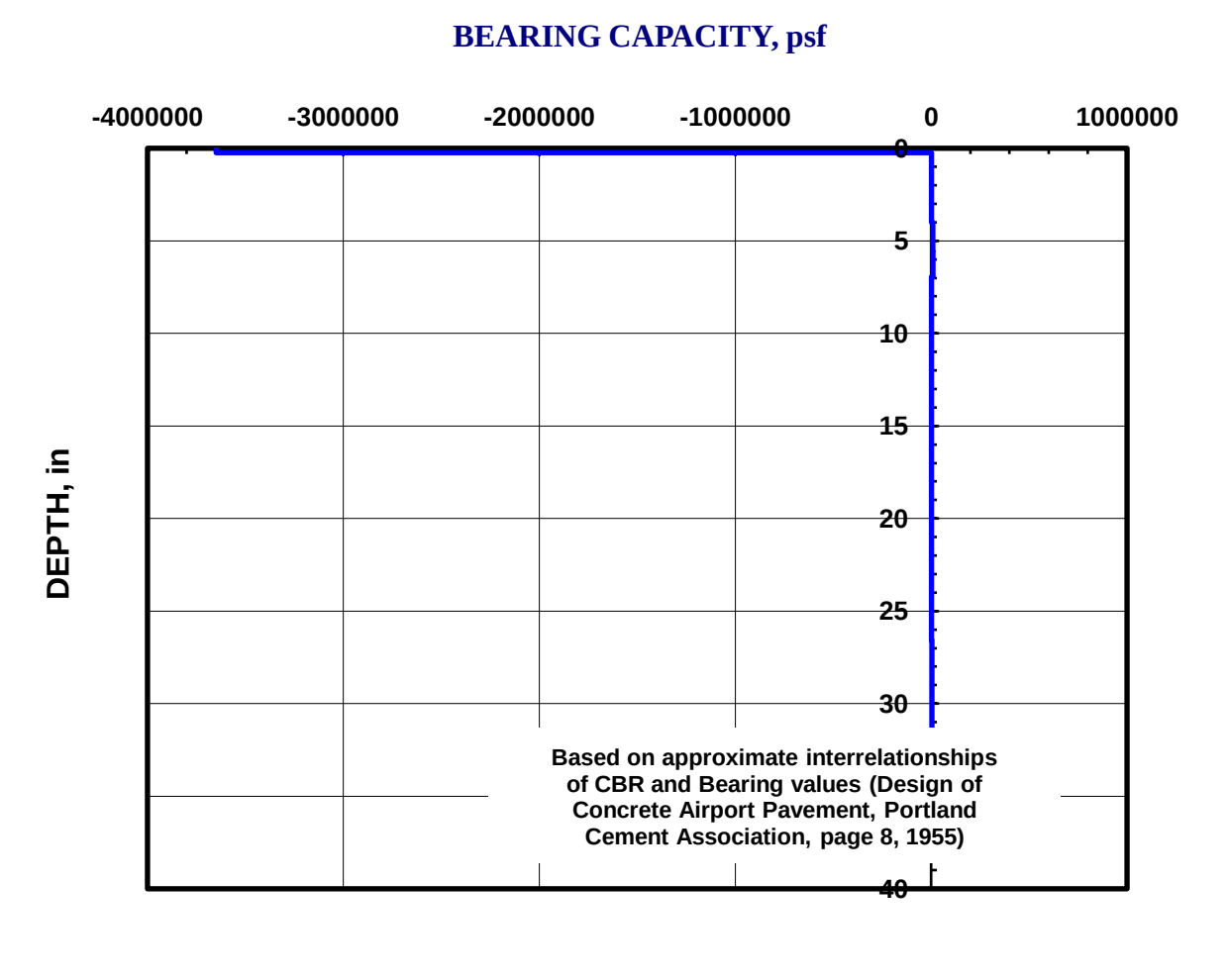
Location: Boring ST-4 **Soil Type(s):** Low plasticity Clay with CBR<10

Hammer
- ○ 10.1 lbs.
- ◉ 17.6 lbs.
- ○ Both hammers used

Soil Type
- ○ CH
- ◉ CL
- ○ All other soils

No. of Blows	Accumulative Penetration (mm)	Type of Hammer
0	0	1
5	6	1
5	102	1
5	142	1
5	176	1
5	259	1
5	374	1
5	521	1
5	675	1
5	737	1
5	794	1





DCP TEST DATA

File Name: 17-3612G

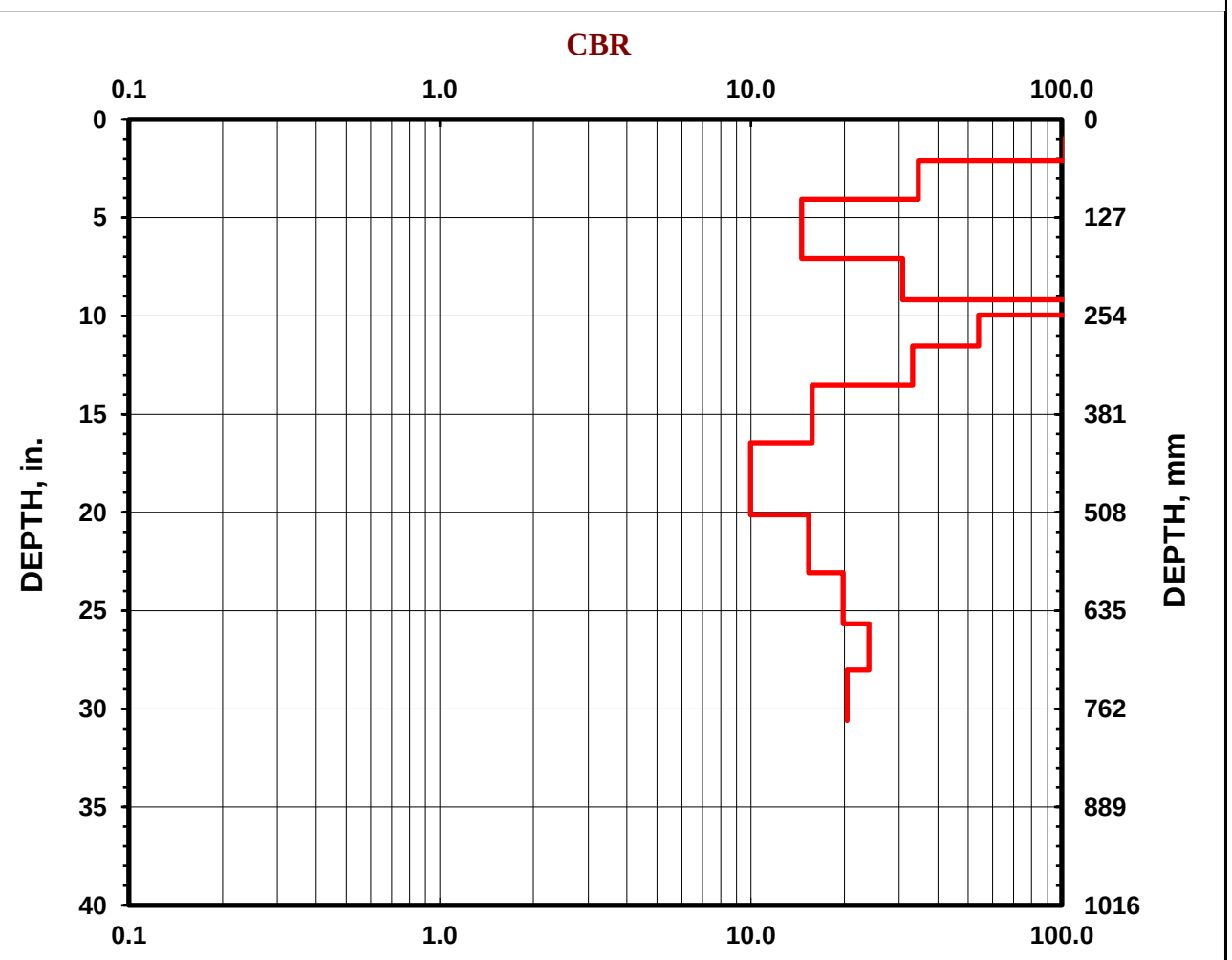
Project: *Makoshika Road Improvements* **Date:** 8-Nov-17

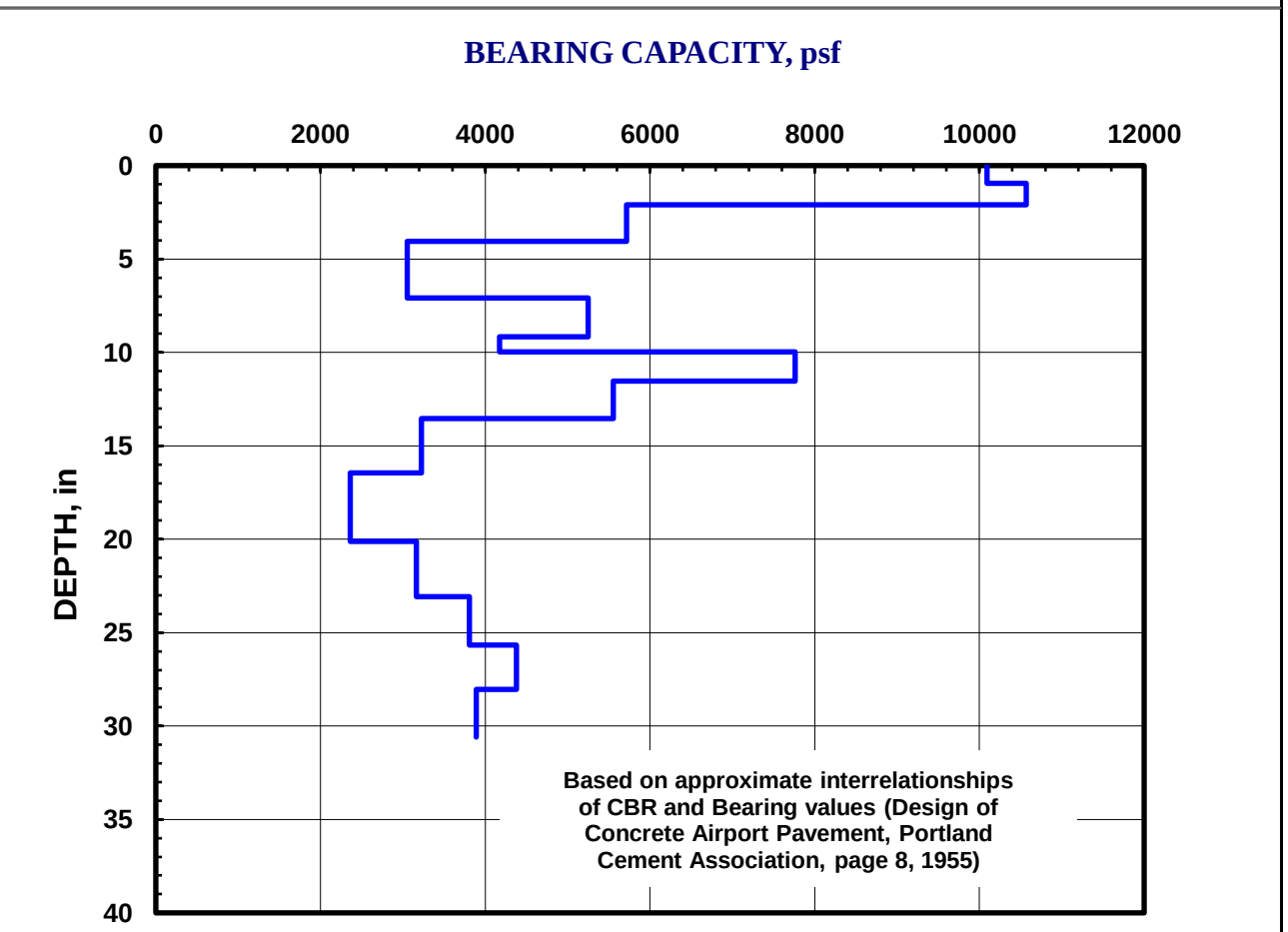
Location: Boring ST-5A **Soil Type(s):** Low plasticity Clay with CBR<10

Hammer
- ○ 10.1 lbs.
- ◉ 17.6 lbs.
- ○ Both hammers used

Soil Type
- ○ CH
- ◉ CL
- ○ All other soils

No. of Blows	Accumulative Penetration (mm)	Type of Hammer
0	0	1
5	24	1
5	53	1
5	103	1
5	180	1
5	233	1
5	253	1
5	293	1
5	344	1
5	418	1
5	511	1
5	586	1
5	652	1
5	712	1
5	777	1





DCP TEST DATA

File Name: 17-3612G

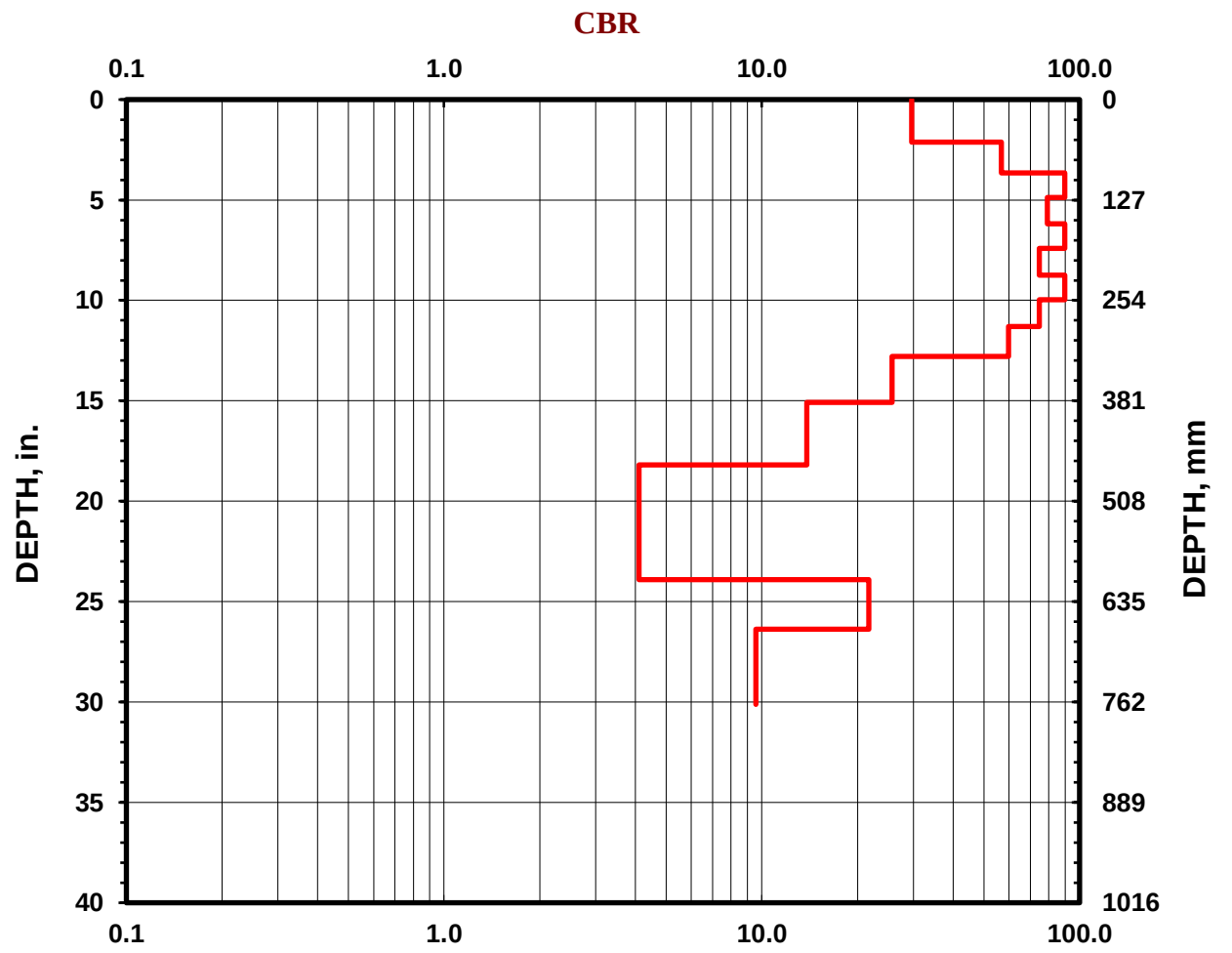
Project: *Makoshika Road Improvements* **Date:** 8-Nov-17

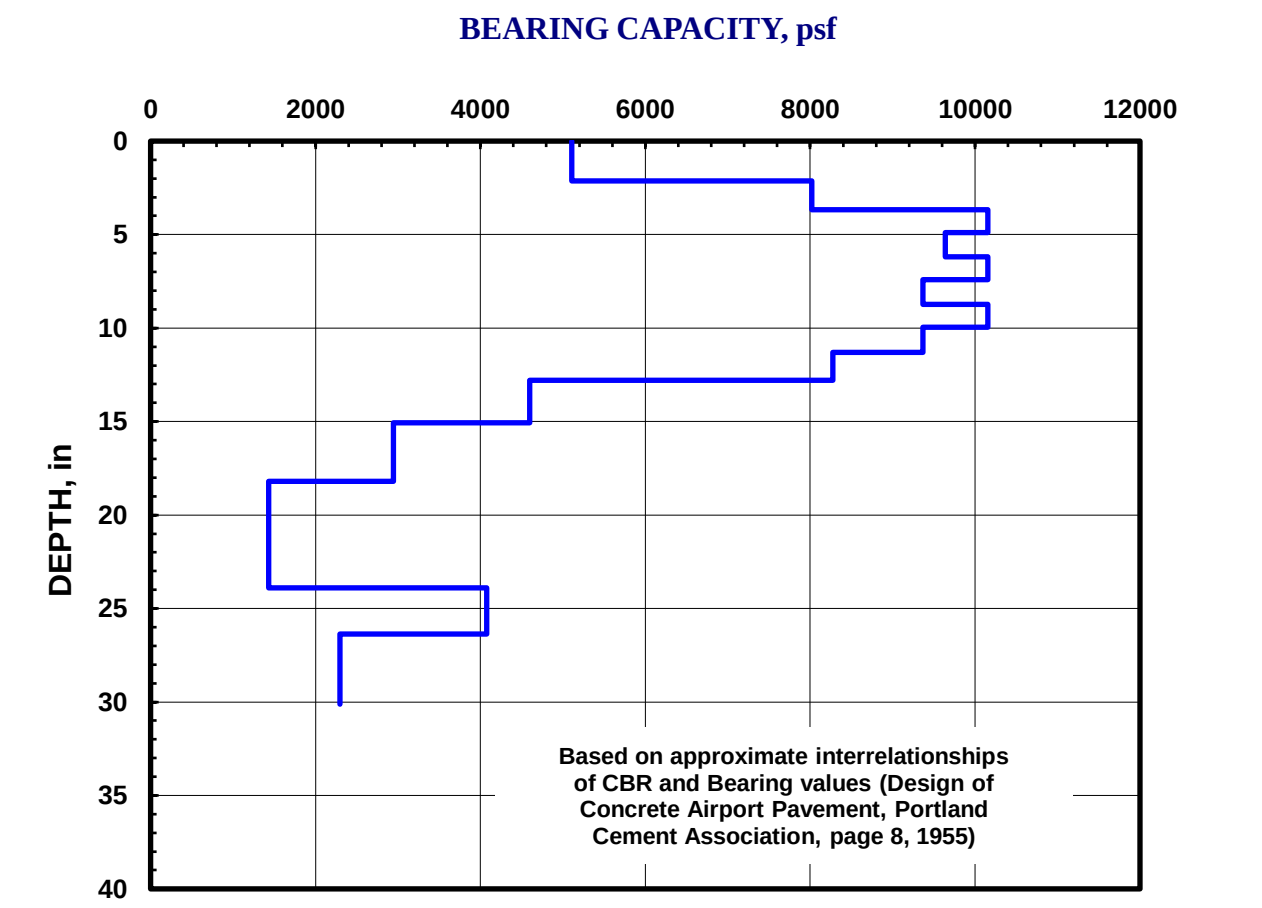
Location: Boring ST-6 **Soil Type(s):** Low plasticity Clay with CBR<10

Hammer
- ○ 10.1 lbs.
- ◉ 17.6 lbs.
- ○ Both hammers used

Soil Type
- ○ CH
- ◉ CL
- ○ All other soils

No. of Blows	Accumulative Penetration (mm)	Type of Hammer
0	0	1
5	54	1
5	93	1
5	124	1
5	157	1
5	188	1
5	222	1
5	253	1
5	287	1
5	325	1
5	383	1
5	462	1
5	607	1
5	670	1
5	765	1





DCP TEST DATA

File Name: 17-3612G

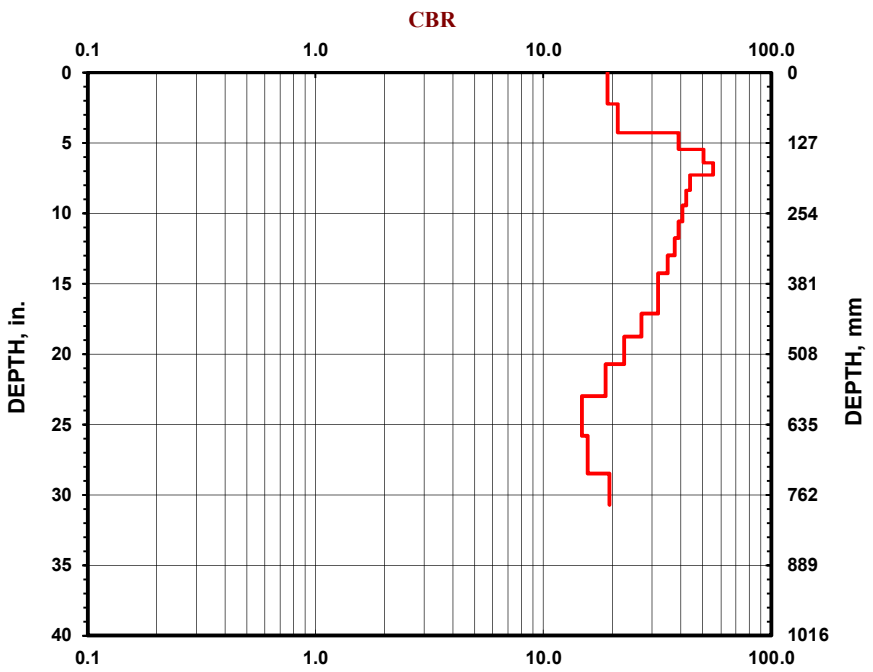
Project: *Makoshika Road Improvements* **Date:** 8-Nov-17

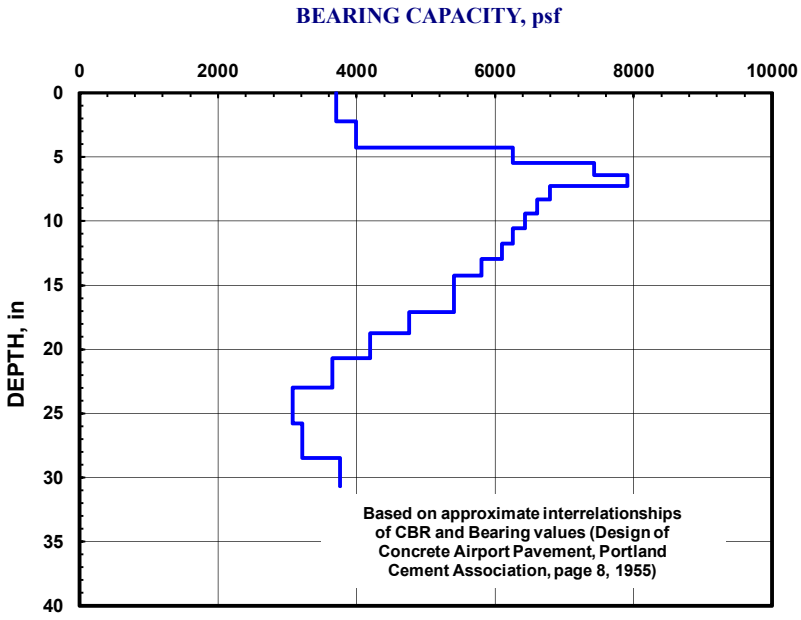
Location: Boring ST-8A **Soil Type(s):** CL to 1.5' over SM

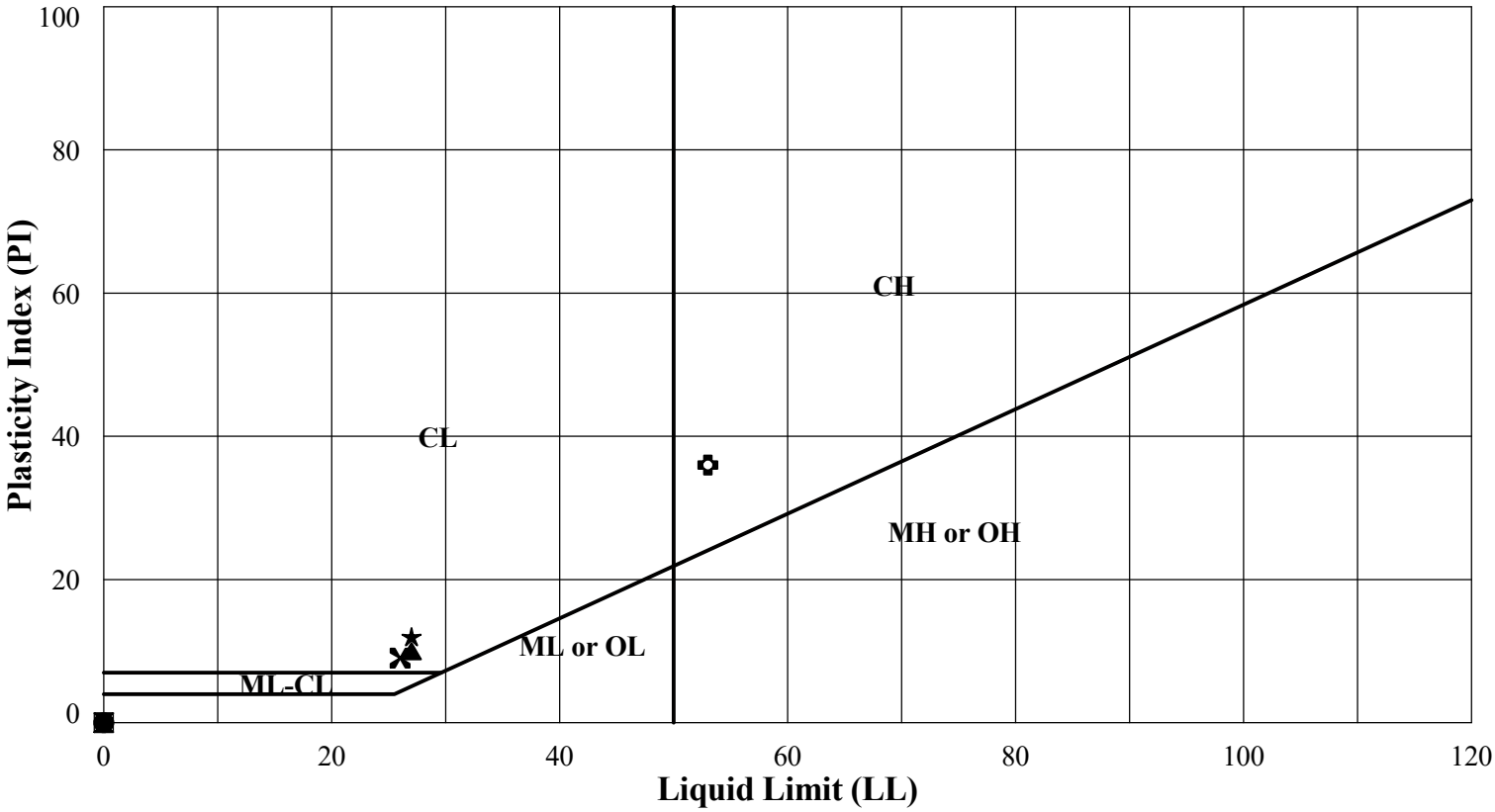
Hammer
- ○ 10.1 lbs.
- ● 17.6 lbs.
- ○ Both hammers used

Soil Type
- ○ CH
- ○ CL
- ● All other soils

No. of Blows	Accumulative Penetration (mm)	Type of Hammer
0	0	1
5	57	1
5	109	1
5	139	1
5	163	1
5	185	1
5	212	1
5	240	1
5	269	1
5	299	1
5	330	1
5	363	1
5	399	1
5	435	1
5	477	1
5	526	1
5	584	1
5	656	1
5	724	1
5	780	1







Legend	Boring	Sample No.	Depth	LL	PL	PI	P 200	MC	Classification
●	ST-1	P-1	1' to 4'	NP	NP	NP	30%	6.0%	SM
⊠	ST-10	TW	5½' to 6½'	NP	NP	NP	56%	14.2%	ML
▲	ST-10	Jar 36	24½' to 25½'	27	17	10	22%	21.3%	SC
★	ST-4	Bulk Bag	1' to 4'	27	15	12	59%	16.8%	CL
✕	ST-6	P-2	1½' to 4'	26	17	9	71%	18.9%	CL
✿	ST-9A	P-3	1½' to 4'	53	17	36	78%	20.4%	CH

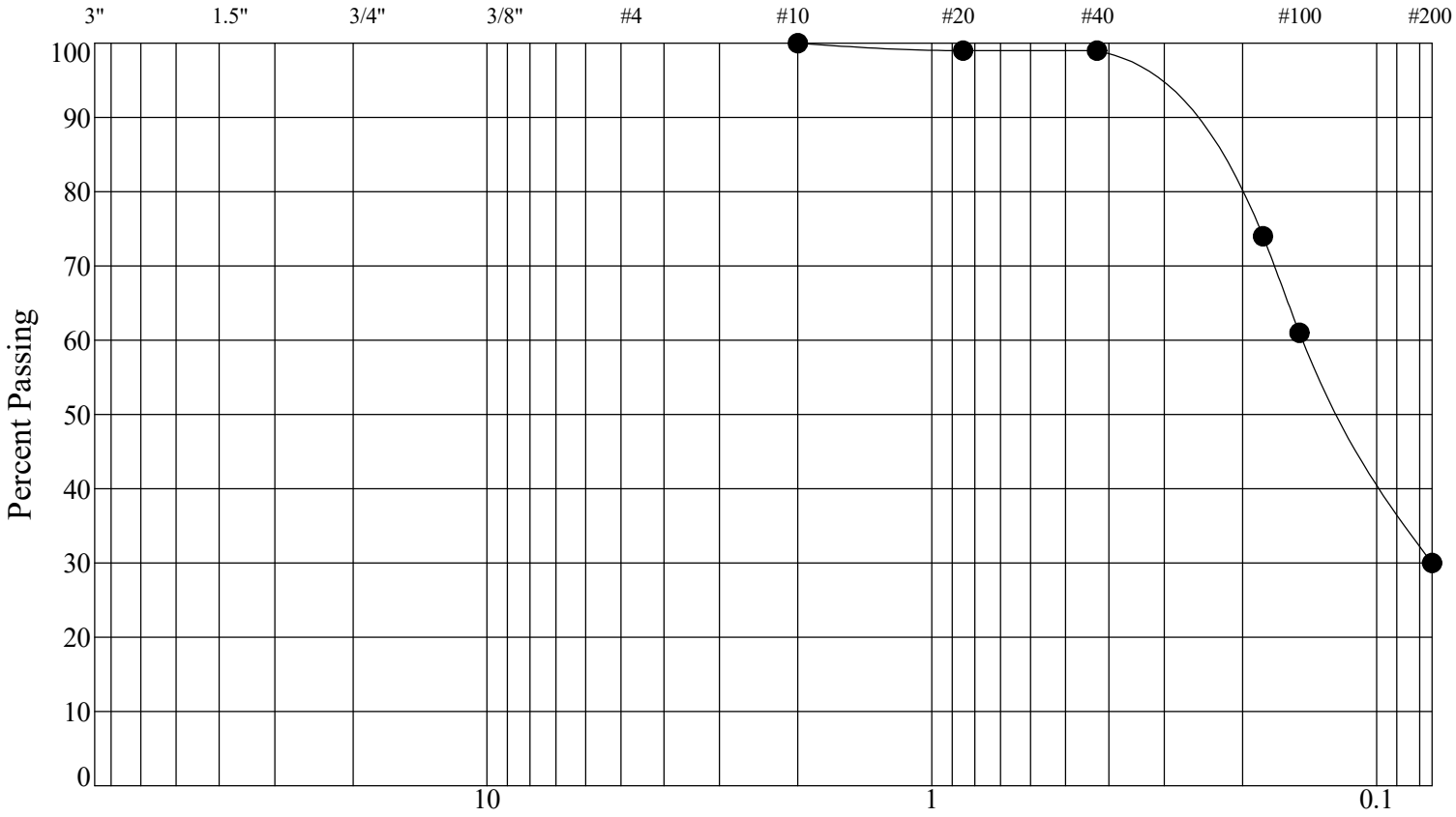
SK GEOTECHNICAL
2511 Holman Avenue
P. O. Box 80190
Billings, MT 59108-0190
Phone: 406.652.3930
Fax: 406.652.3944

Atterberg Limits Tests

Project Number: 17-3612G
Makoshika State Park Road Improvements
Glendive, Montana

1/8/18

Sieve Size



Particle Size in Millimeters

Gravel		Sand		
coarse	fine	coarse	medium	fine

Percent Passing U.S. Standard Sieve Size

3"	1 1/2"	3/4"	3/8"	#4	#10	#20	#40	#80	#100	#200
					100	99	99	74	61	30

Boring No.: ST-1
Sample No.: P-1
Depth: 1' to 4'

Date Received: 11/13/2017

Liquid Limit:	NP
Plastic Limit:	NP
Plasticity Index:	NP
Classification:	SM
Moisture Content:	6.0%

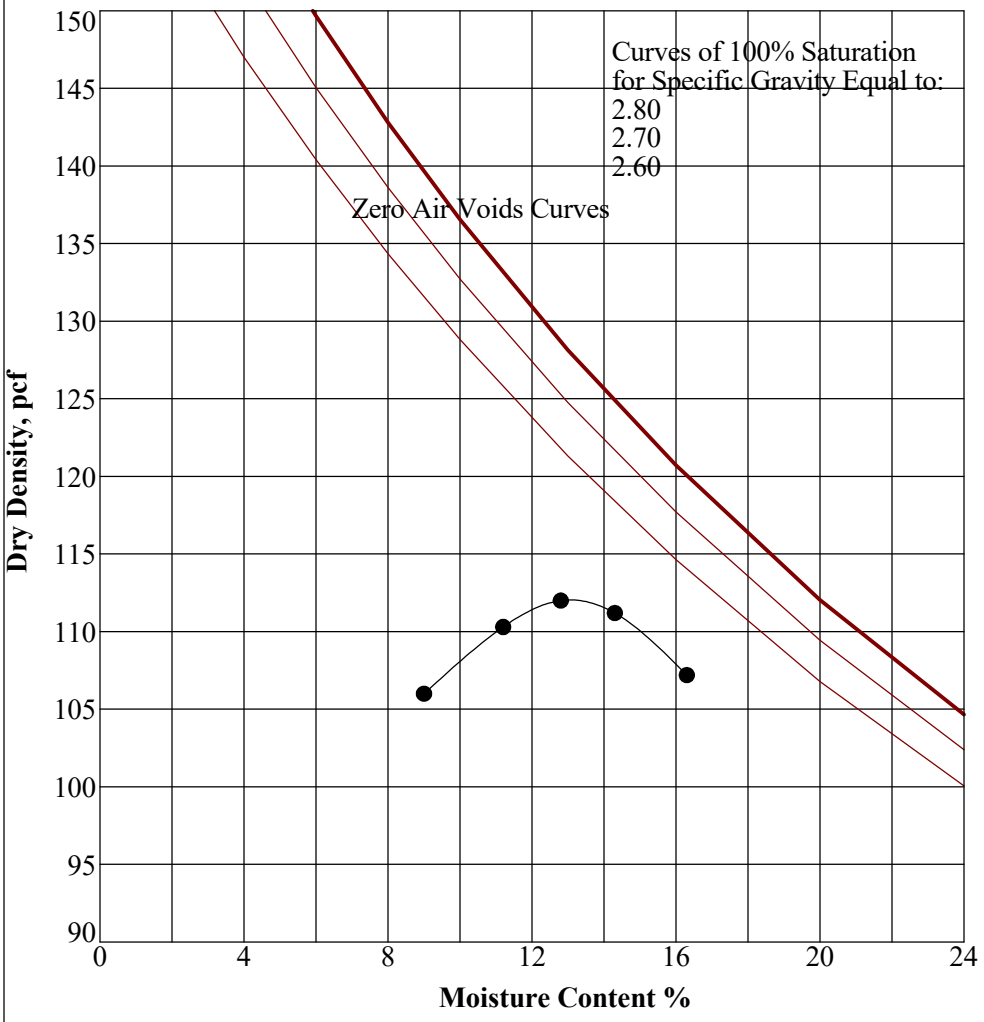
Percent Gravel: 0.0
Percent Sand: 70.0
Percent Silt + Clay: 30.0
ASTM Group Name: SILTY SAND

SK GEOTECHNICAL
2511 Holman Avenue
P. O. Box 80190
Billings, MT 59108-0190
Phone: 406.652.3930
Fax: 406.652.3944

Sieve Analysis

Project Number: 17-3612G
Makoshika State Park Road Improvements
Glendive, Montana

1/8/18



ASTM D 698 Method A

Maximum Dry Density, pcf	Optimum Moisture Content %
112.0	**13.0**

Rammer Type: Mechanical
Preparation Method: Moist

Soil Description (Visual-Manual)

Silty Sand [SM]

Sieve Size	% Retained
1 1/2"	0
3/4"	0
3/8"	0
#4	0

Sample No: Bulk Bag
Lab Sample No: P-1
Date Sampled: 11/08/2017
Sampled By: Drill Crew
Date Received: 11/13/2017
Sampled From: ST-1

Depth: 1' to 4'
Performed by: MRW, CJP/SKG
Date Performed: 11/15/2017

Comments

Remarks

SK GEOTECHNICAL
2511 Holman Avenue
P. O. Box 80190
Billings, MT 59108-0190
Phone: 406.652.3930
Fax: 406.652.3944

Laboratory Compaction Characteristics of Soil (Proctor)

Project No.: 17-3612G
Makoshika State Park Road Improvements
Glendive, Montana

PROCTOR

P-1

1/8/18

California Bearing Ratio

ASTM D 1883 /AASHTO T 193

Project: 17-3612G Geotechnical Evaluation
Makoshika Park

Date: 01/08/18

Boring: ST-1 Sample: Bulk Bag Depth: 1 - 4 '

Description: Silty Sand (SM)

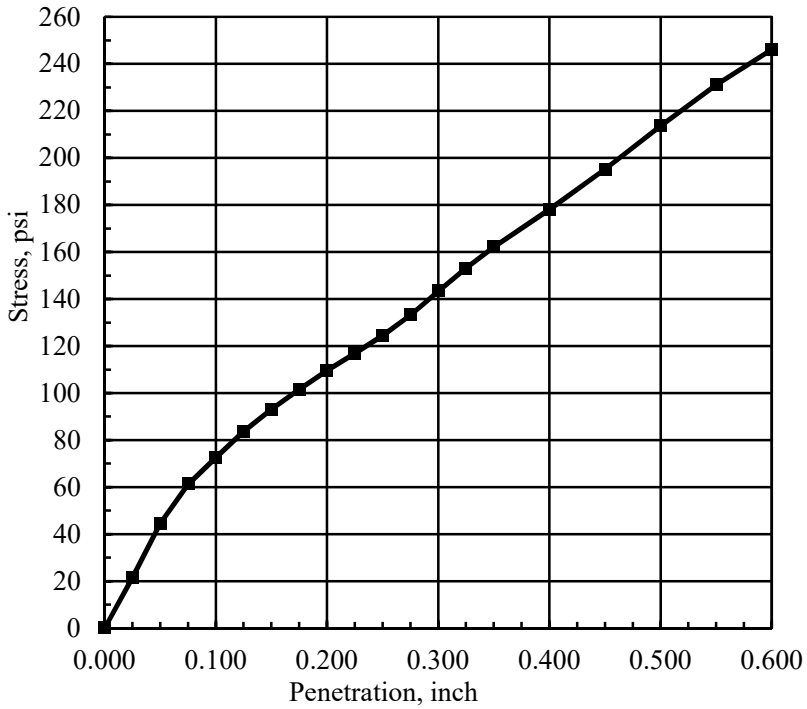
MDD, pcf	OMC, %	Method
111.7	12.8	D 698

Compaction

Initial				Final			
Weight, g	**MC%**	**Dry, pcf**	**Comp%**	**Weight, g**	**MC%**	**Dry, pcf**	**Comp%**
4072.0	12.8%	106.1	95.0%	4426.9	22.6%	106.1	94.9%

Swell **CBR**

Surcharge		Initial	Final	Swell	Surcharge	CBR @	CBR @
Weight, lbs	**Press, psf**	**Dial, "**	**Dial, "**	**%**	**Press, psf**	**0.1 in.**	**0.2 in.**
22.7	119.5	0.5000	0.5020	0.0%	119.8	7.3	7.3

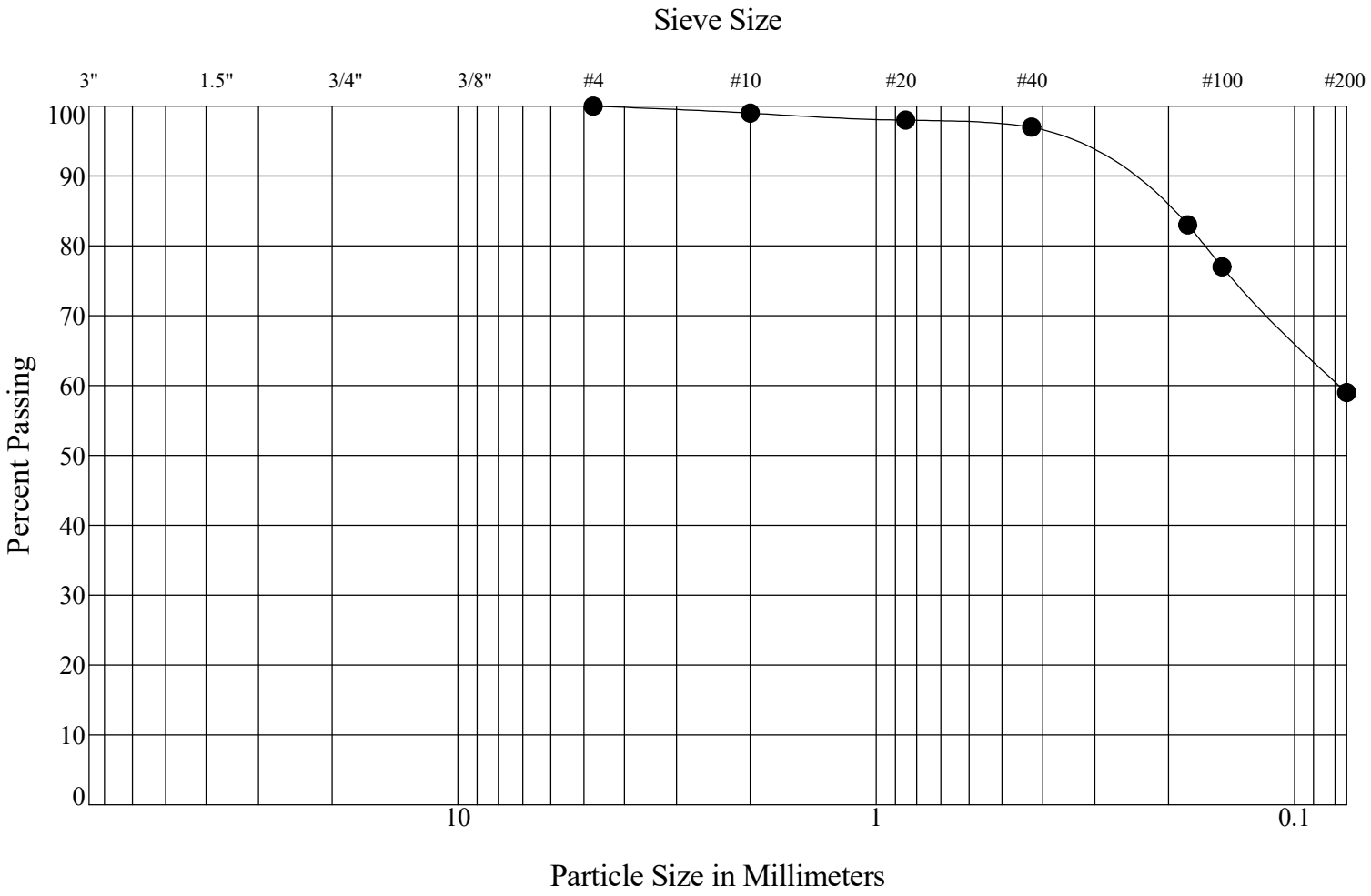


Design Values:

CBR @ 0.1 inch **7.3**

CBR @ 0.2 inch **7.3**

2511 Holman Avenue, P. O. Box 80190, Billings, Montana 59108-0190 Phone (406) 652-3930; Fax (406) 652-3944



Gravel		Sand		
coarse	fine	coarse	medium	fine

Percent Passing U.S. Standard Sieve Size

3"	1 1/2"	3/4"	3/8"	#4	#10	#20	#40	#80	#100	#200
				100	99	98	97	83	77	59

Boring No.: ST-4
Sample No.: Bulk Bag
Depth: 1' to 4'

Date Received: 11/13/2017

Liquid Limit:	27
Plastic Limit:	15
Plasticity Index:	12
Classification:	CL
Moisture Content:	16.8%

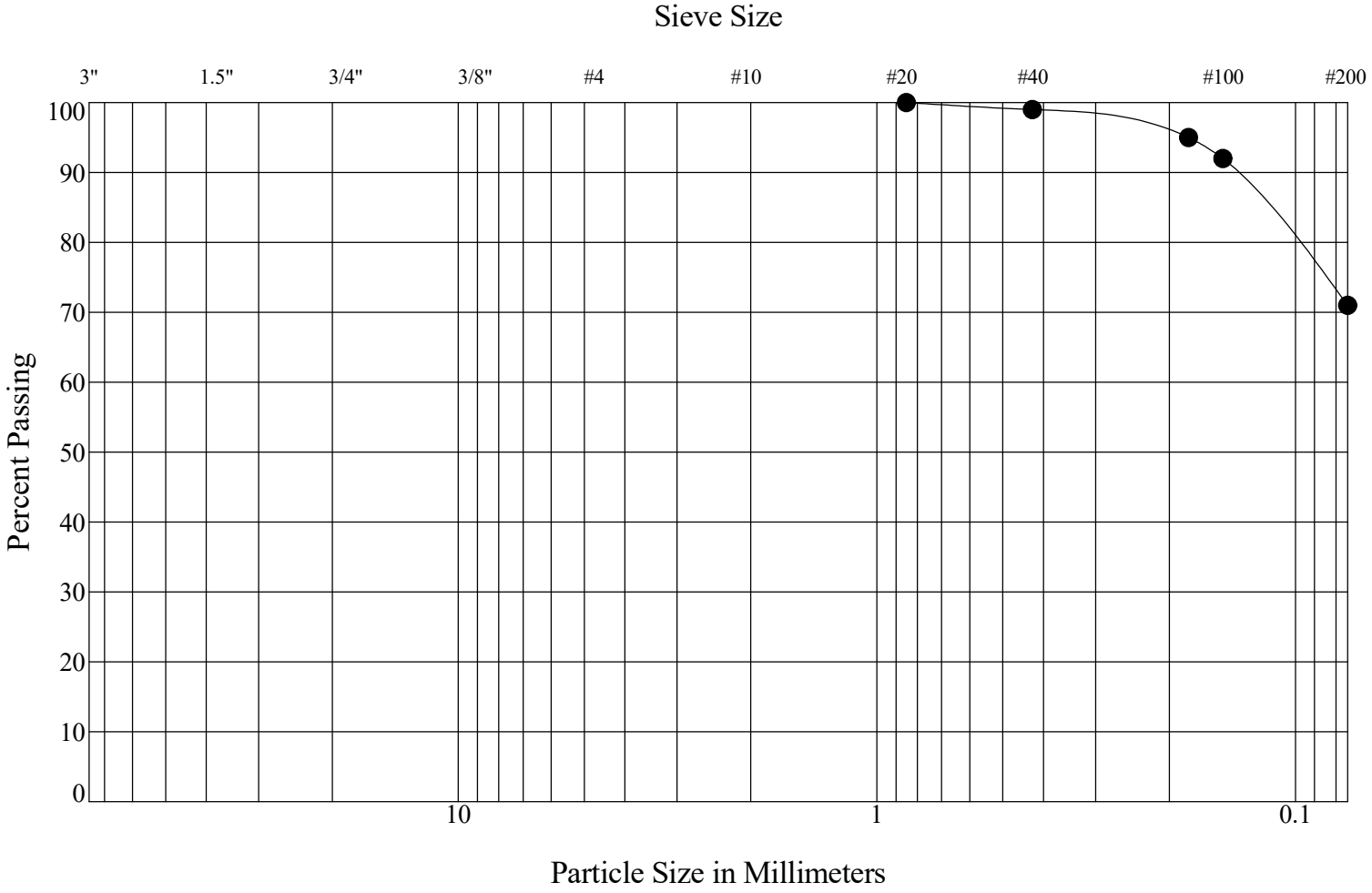
Percent Gravel: 0.0
Percent Sand: 41.0
Percent Silt + Clay: 59.0
ASTM Group Name: SANDY LEAN CLAY

SK GEOTECHNICAL
2511 Holman Avenue
P. O. Box 80190
Billings, MT 59108-0190
Phone: 406.652.3930
Fax: 406.652.3944

Sieve Analysis

Project Number: 17-3612G
Makoshika State Park Road Improvements
Glendive, Montana

1/8/18



Gravel		Sand		
coarse	fine	coarse	medium	fine

Percent Passing U.S. Standard Sieve Size

3"	1 1/2"	3/4"	3/8"	#4	#10	#20	#40	#80	#100	#200
						100	99	95	92	71

Boring No.: ST-6
Sample No.: P-2
Depth: 1½' to 4'

Date Received: 11/13/2017

Liquid Limit:	26
Plastic Limit:	17
Plasticity Index:	9
Classification:	CL
Moisture Content:	18.9%

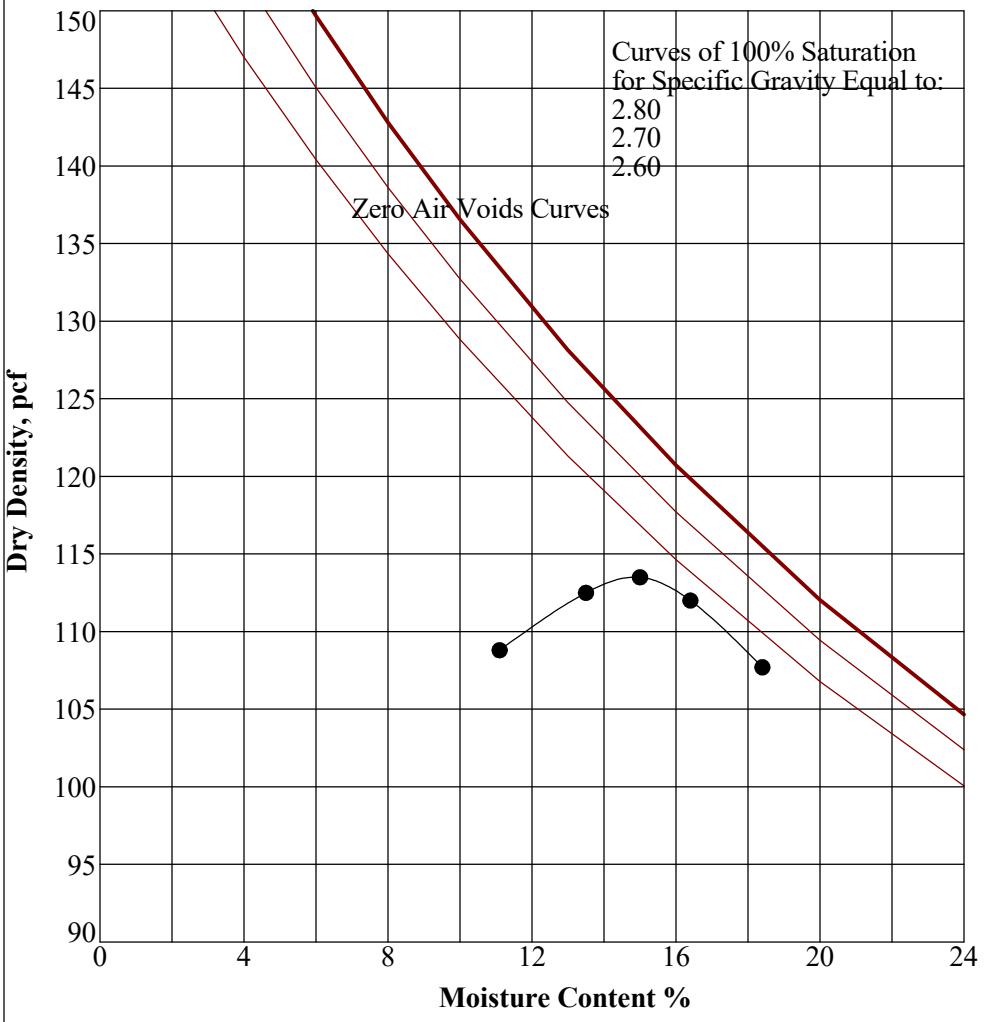
Percent Gravel: 0.0
Percent Sand: 29.0
Percent Silt + Clay: 71.0
ASTM Group Name: LEAN CLAY with SAND

SK GEOTECHNICAL
2511 Holman Avenue
P. O. Box 80190
Billings, MT 59108-0190
Phone: 406.652.3930
Fax: 406.652.3944

Sieve Analysis

Project Number: 17-3612G
Makoshika State Park Road Improvements
Glendive, Montana

1/8/18



ASTM D 698 Method A

Maximum Dry Density, pcf	Optimum Moisture Content %
113.5	**15.0**

Rammer Type: Mechanical
Preparation Method: Moist

Soil Description (Visual-Manual)

Lean Clay With Sand [CL]

Sieve Size	% Retained
1 1/2"	0
3/4"	0
3/8"	0
#4	0

Sample No: Bulk Bag
Lab Sample No: P-2
Date Sampled: 11/08/2017
Sampled By: Drill Crew
Date Received: 11/13/2017
Sampled From: ST-6

Depth: 1½' to 4'
Performed by: MRW/SKG
Date Performed: 11/15/2017

Comments

Remarks

SK GEOTECHNICAL
2511 Holman Avenue
P. O. Box 80190
Billings, MT 59108-0190
Phone: 406.652.3930
Fax: 406.652.3944

Laboratory Compaction Characteristics of Soil (Proctor)

Project No.: 17-3612G
Makoshika State Park Road Improvements
Glendive, Montana

PROCTOR

P-2

1/8/18

California Bearing Ratio

ASTM D 1883 /AASHTO T 193

Project: 17-3612G Geotechnical Evaluation
Makoshika Park

Date: 01/08/18

Boring: ST-6 Sample: Bulk Bag Depth: 1½ - 4 '

Description: Lean Clay with Sand (CL)

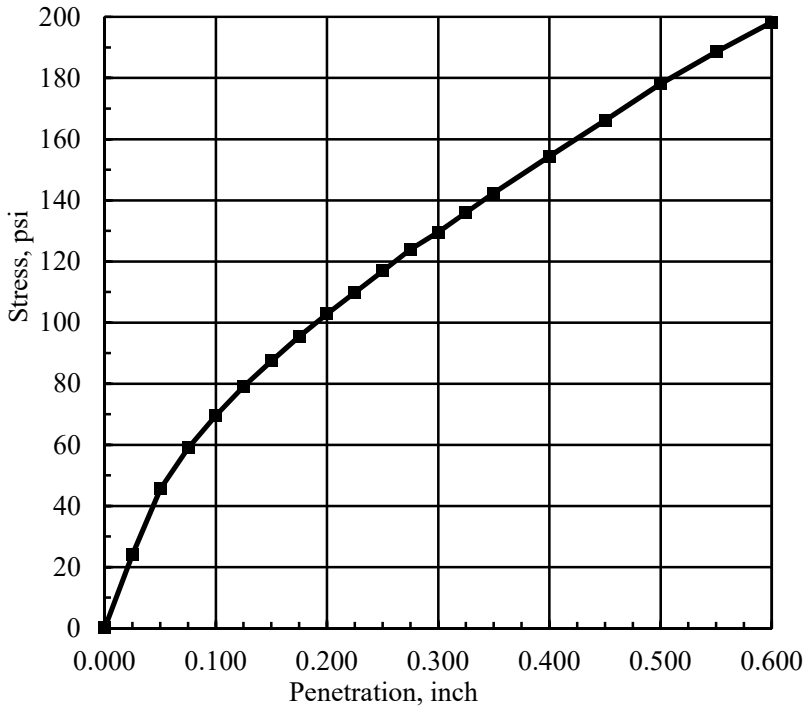
MDD, pcf	OMC, %	Method
113.1	14.9	D 698

Compaction

Initial				Final			
Weight, g	**MC%**	**Dry, pcf**	**Comp%**	**Weight, g**	**MC%**	**Dry, pcf**	**Comp%**
4200.0	14.9%	107.4	95.0%	4492.5	22.9%	107.4	94.9%

Swell **CBR**

Surcharge		Initial	Final	Swell	Surcharge	CBR @	CBR @
Weight, lbs	**Press, psf**	**Dial, "**	**Dial, "**	**%**	**Press, psf**	**0.1 in.**	**0.2 in.**
22.6	119.0	0.5000	0.5030	0.1%	119.2	7.0	6.9

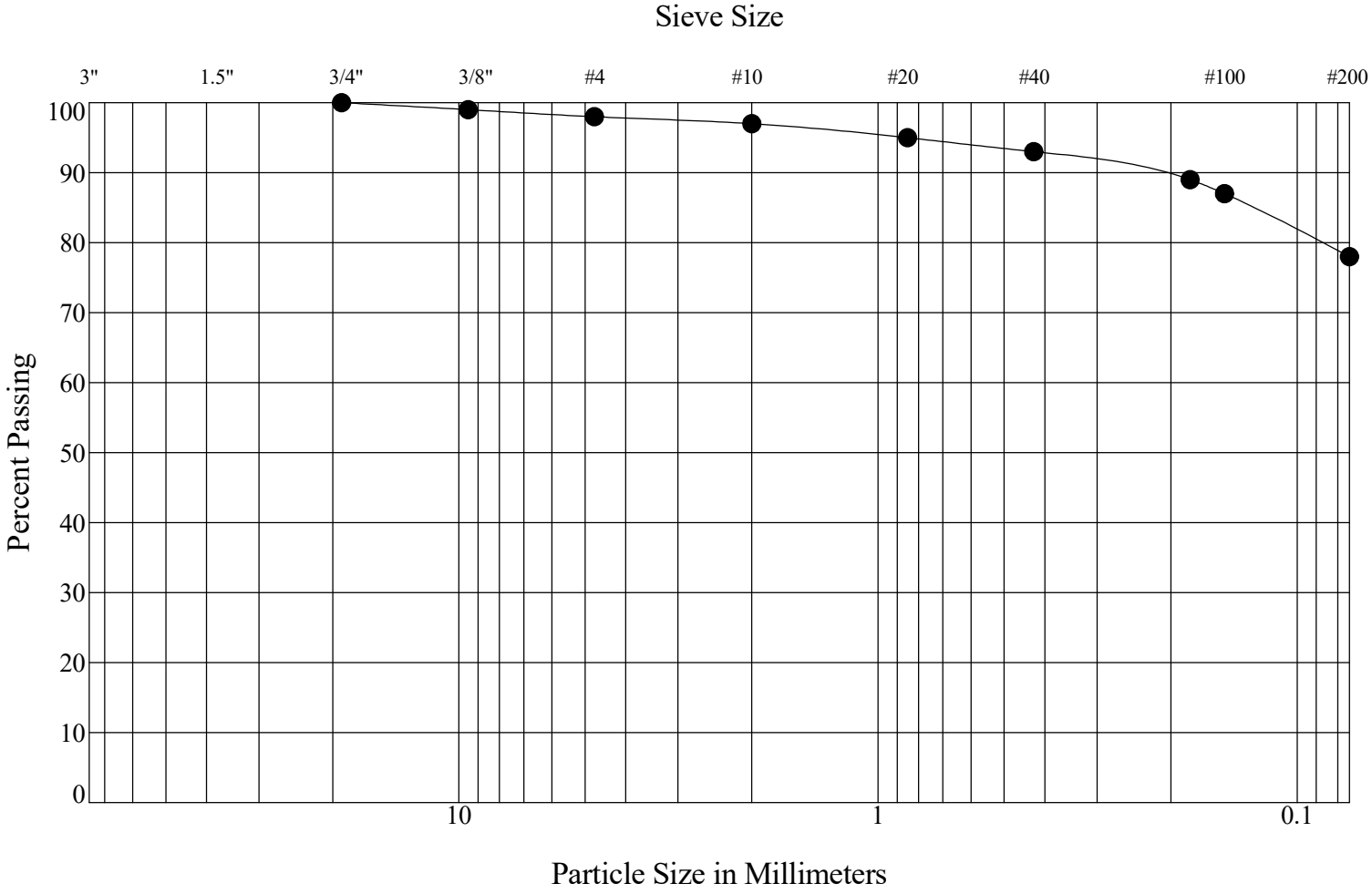


Design Values:

CBR @ 0.1 inch **7.0**

CBR @ 0.2 inch **6.9**

2511 Holman Avenue, P. O. Box 80190, Billings, Montana 59108-0190 Phone (406) 652-3930; Fax (406) 652-3944



Gravel		Sand		
coarse	fine	coarse	medium	fine

Percent Passing U.S. Standard Sieve Size

3"	1 1/2"	3/4"	3/8"	#4	#10	#20	#40	#80	#100	#200
		100	99	98	97	95	93	89	87	78

Boring No.: ST-9A
Sample No.: P-3
Depth: 1½' to 4'

Date Received: 11/13/2017

Liquid Limit:	53
Plastic Limit:	17
Plasticity Index:	36
Classification:	CH
Moisture Content:	20.4%

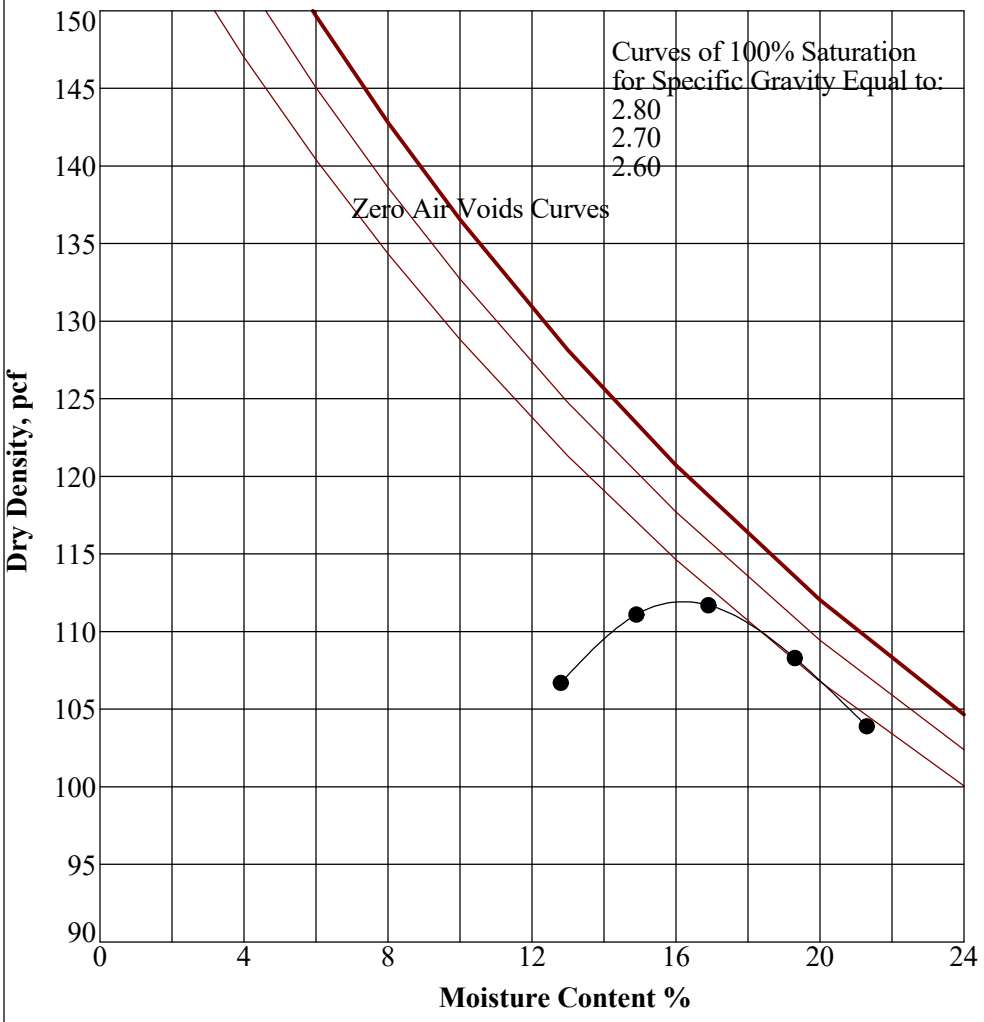
Percent Gravel: 2.0
Percent Sand: 20.0
Percent Silt + Clay: 78.0
ASTM Group Name: FAT CLAY with SAND

SK GEOTECHNICAL
2511 Holman Avenue
P. O. Box 80190
Billings, MT 59108-0190
Phone: 406.652.3930
Fax: 406.652.3944

Sieve Analysis

Project Number: 17-3612G
Makoshika State Park Road Improvements
Glendive, Montana

1/8/18



ASTM D 698 Method A

Maximum Dry Density, pcf	Optimum Moisture Content %
111.9	**16.2**

Rammer Type: Mechanical
Preparation Method: Moist

Soil Description (Visual-Manual)

Fat Clay With Sand [CH]

Sieve Size	% Retained
1 1/2"	0
3/4"	0
3/8"	1
#4	2

Sample No: Bulk Bag
Lab Sample No: P-3
Date Sampled: 11/08/2017
Sampled By: Drill Crew
Date Received: 11/13/2017
Sampled From: ST-9A

Depth: 1½' to 4'
Performed by: RJQ/SKG
Date Performed: 11/16/2017

Comments

Remarks

SK GEOTECHNICAL
2511 Holman Avenue
P. O. Box 80190
Billings, MT 59108-0190
Phone: 406.652.3930
Fax: 406.652.3944

Laboratory Compaction Characteristics of Soil (Proctor)

Project No.: 17-3612G
Makoshika State Park Road Improvements
Glendive, Montana

PROCTOR

P-3

1/8/18

California Bearing Ratio

ASTM D 1883 /AASHTO T 193

Project: 17-3612G Geotechnical Evaluation
Makoshika Park

Date: 01/08/18

Boring: ST-9A Sample: Bulk Bag Depth: 1½ - 4 '

Description: Fat Clay with Sand (CH)

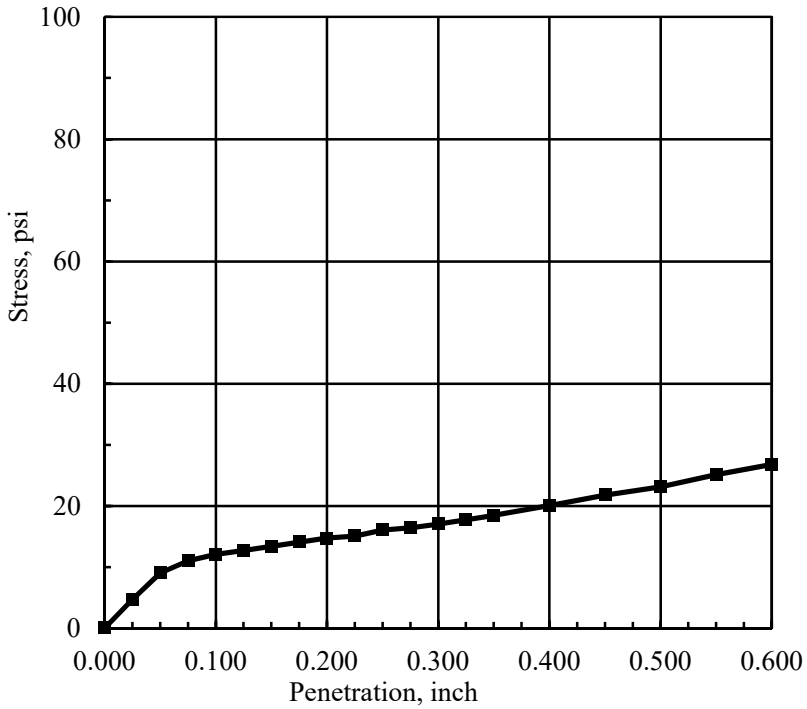
MDD, pcf	OMC, %	Method
111.9	16.2	D 698

Compaction

Initial				Final			
Weight, g	**MC%**	**Dry, pcf**	**Comp%**	**Weight, g**	**MC%**	**Dry, pcf**	**Comp%**
4202.0	16.2%	106.3	95.0%	4819.8	33.3%	104.0	92.9%

Swell **CBR**

Surcharge		Initial	Final	Swell	Surcharge	CBR @	CBR @
Weight, lbs	**Press, psf**	**Dial, "**	**Dial, "**	**%**	**Press, psf**	**0.1 in.**	**0.2 in.**
22.3	117.5	0.5000	0.6010	2.2%	117.5	1.2	1.0

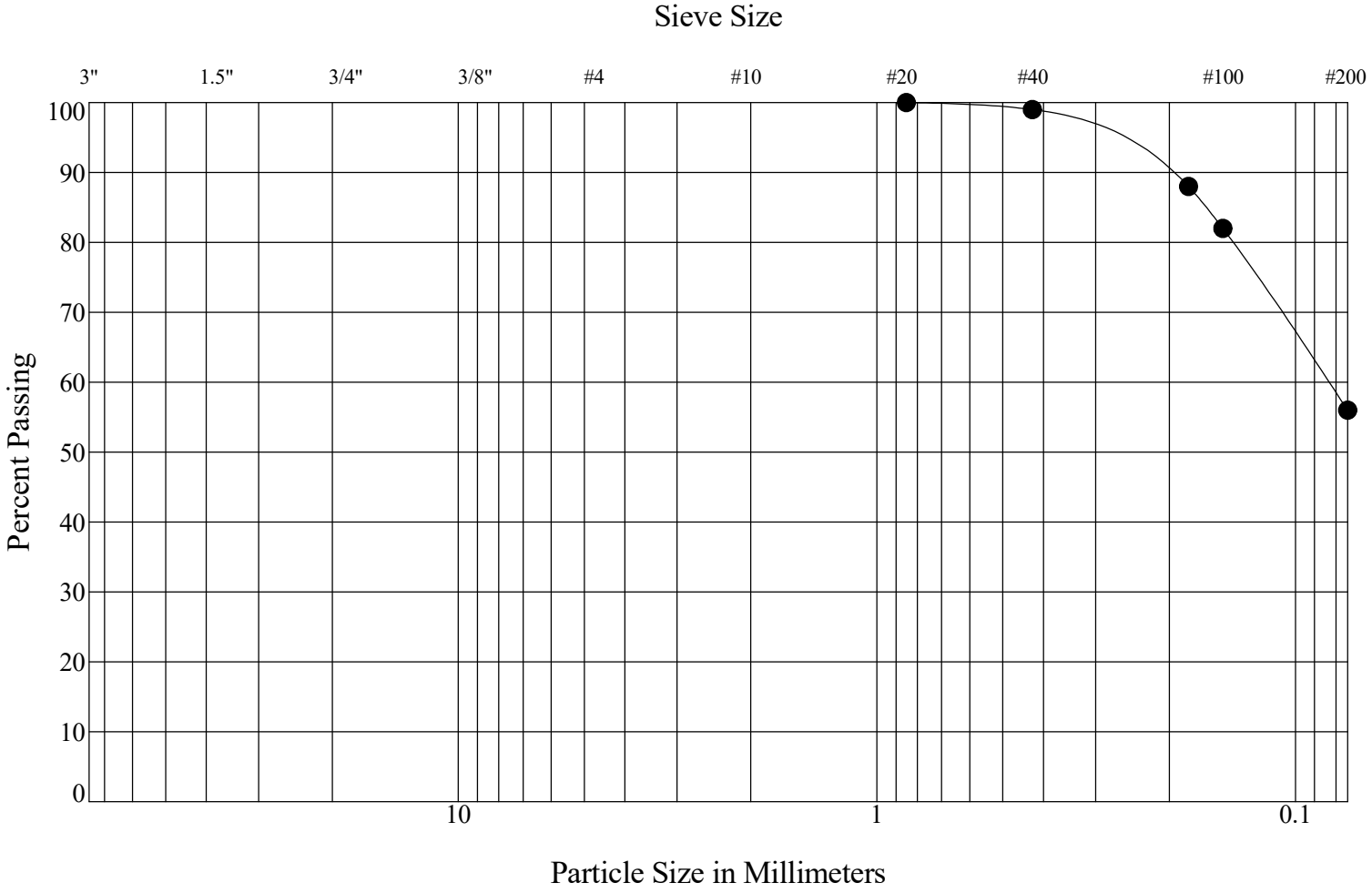


Design Values:

CBR @ 0.1 inch **1.2**

CBR @ 0.2 inch **1.0**

2511 Holman Avenue, P. O. Box 80190, Billings, Montana 59108-0190 Phone (406) 652-3930; Fax (406) 652-3944



Gravel		Sand		
coarse	fine	coarse	medium	fine

Percent Passing U.S. Standard Sieve Size

3"	1 1/2"	3/4"	3/8"	#4	#10	#20	#40	#80	#100	#200
						100	99	88	82	56

Boring No.: ST-10
Sample No.: TW
Depth: 5½' to 6½'

Date Received: 11/13/2017

Liquid Limit:	NP
Plastic Limit:	NP
Plasticity Index:	NP
Classification:	ML
Moisture Content:	14.2%

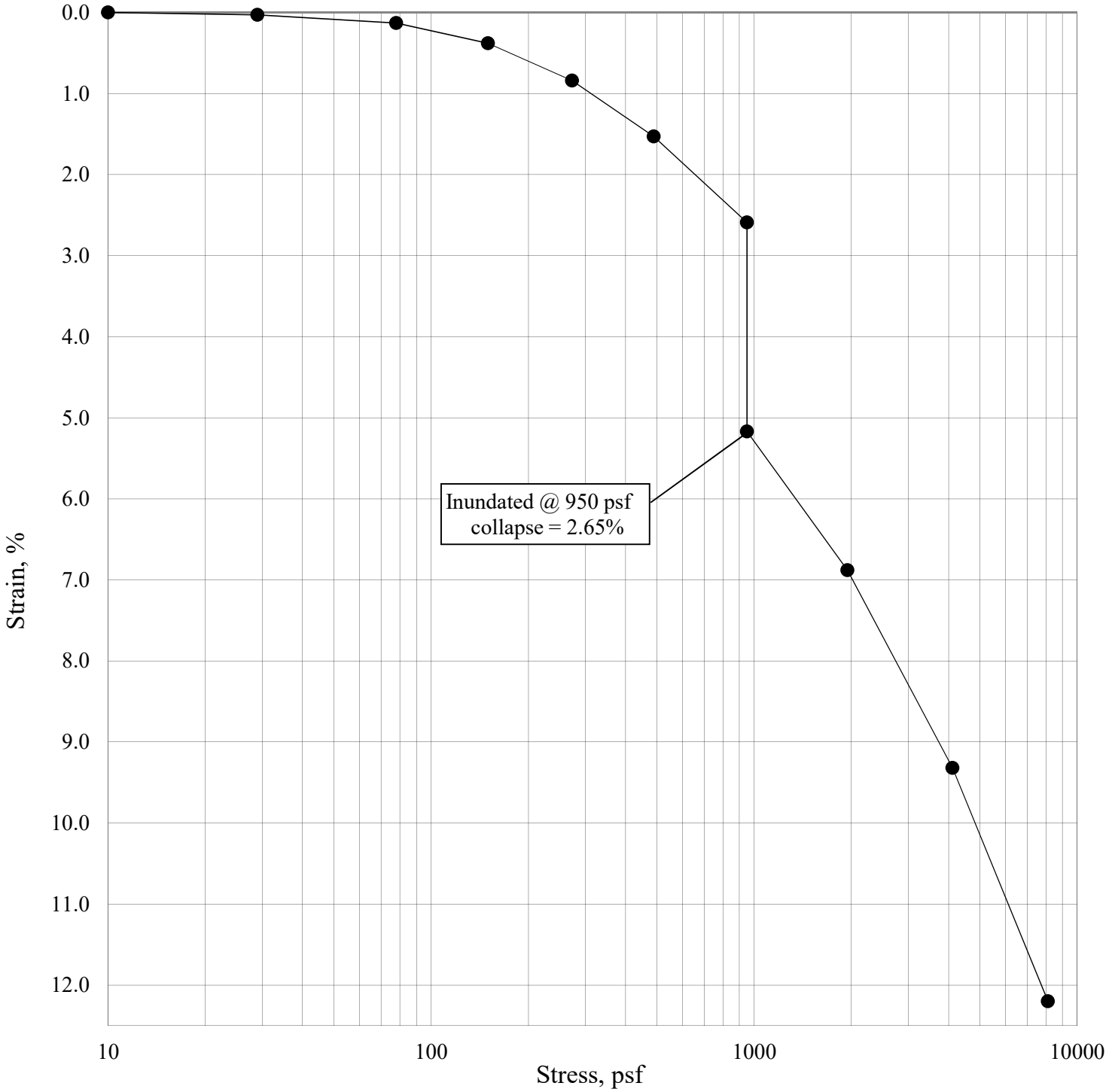
Percent Gravel: 0.0
Percent Sand: 44.0
Percent Silt + Clay: 56.0
ASTM Group Name: SANDY SILT

SK GEOTECHNICAL
2511 Holman Avenue
P. O. Box 80190
Billings, MT 59108-0190
Phone: 406.652.3930
Fax: 406.652.3944

Sieve Analysis

Project Number: 17-3612G
Makoshika State Park Road Improvements
Glendive, Montana

1/8/18



				Initial Dry Density (pcf)	Initial Moisture Content (%)
Boring No.	ST-10	Depth:	5½ - 6½ '	**81.1**	**14.2**
Sampled By:	Drill Crew	Date Received:	11/14/17		

Soil Description: Sandy Silt, fine-grained, trace lignite, olive brown, moist. (ML)

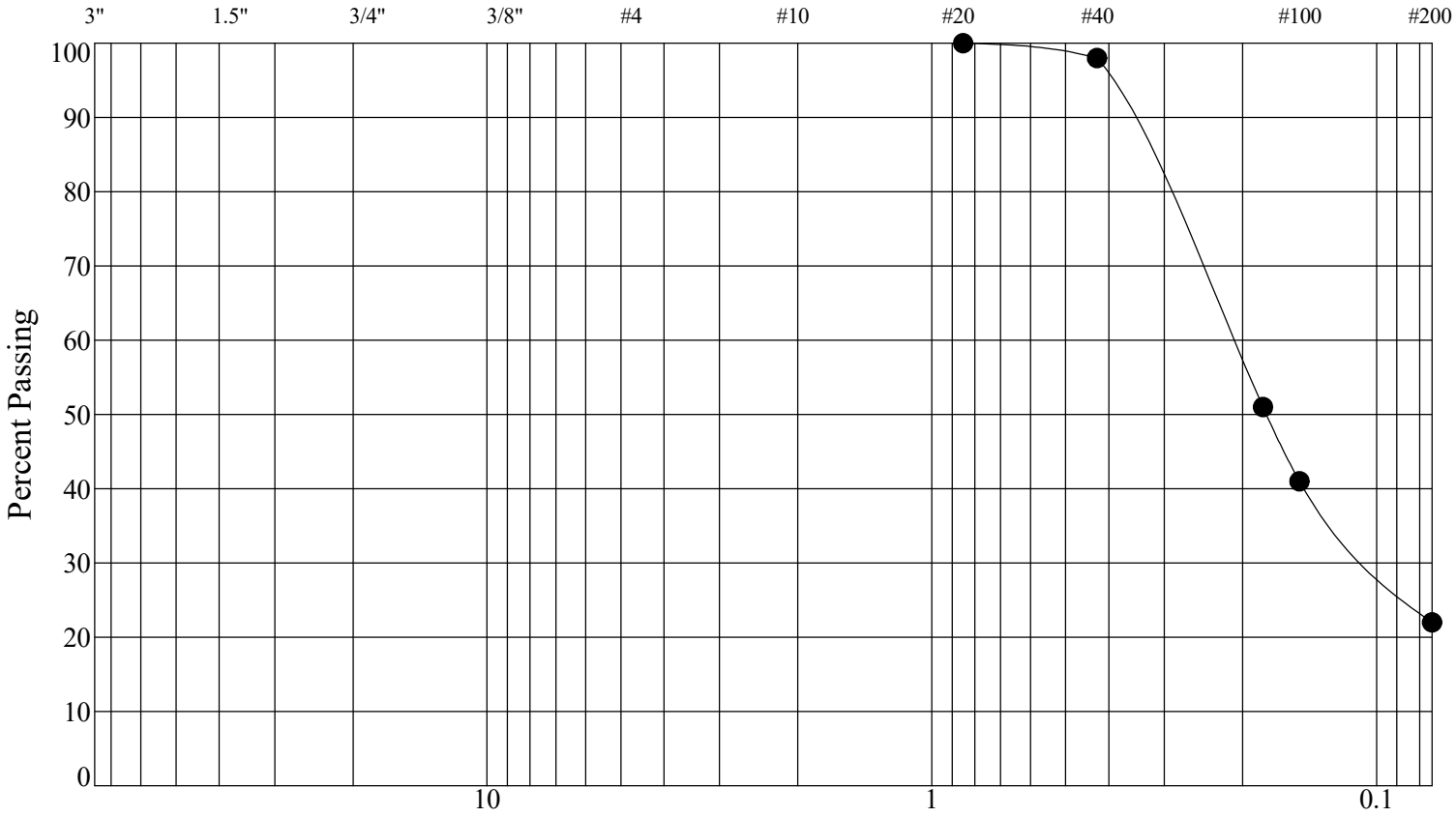
1/8/18

SK GEOTECHNICAL
P. O. Box 80190
Billings, MT 59108-0190
Phone: 406.652.3930
Fax: 406.652.3944

Consolidation/Swell Test

Project Number: 17-3612G
Makoshika State Park
Glendive, Montana

Sieve Size



Particle Size in Millimeters

Gravel		Sand		
coarse	fine	coarse	medium	fine

Percent Passing U.S. Standard Sieve Size

3"	1 1/2"	3/4"	3/8"	#4	#10	#20	#40	#80	#100	#200
						100	98	51	41	22

Boring No.: ST-10
Sample No.: Jar 36
Depth: 24½' to 25½'

Date Received: 11/13/2017

Liquid Limit:	27
Plastic Limit:	17
Plasticity Index:	10
Classification:	SC
Moisture Content:	21.3%

Percent Gravel: 0.0
Percent Sand: 78.0
Percent Silt + Clay: 22.0
ASTM Group Name: CLAYEY SAND

SK GEOTECHNICAL
2511 Holman Avenue
P. O. Box 80190
Billings, MT 59108-0190
Phone: 406.652.3930
Fax: 406.652.3944

Sieve Analysis

Project Number: 17-3612G
Makoshika State Park Road Improvements
Glendive, Montana

1/8/18

Simplified Traffic Analysis

==========

DARWin(tm) - Pavement Design

A Proprietary AASHTOWARE(tm)
Computer Software Product

Flexible Structural Design Module

Project Description
Makoshika State Park Road Improvements Glendive, Montana

Flexible Structural Design Module Data
18-kip ESALs Over Initial Performance Period:
Initial Serviceability:
Terminal Serviceability:
Reliability Level (%):
Overall Standard Deviation:
Roadbed Soil Resilient Modulus (PSI):
Stage Construction: 1

Calculated Structural Number: .00

Simple ESAL Calculation
Initial Performance Period (years): 20
Initial Two-Way Daily Traffic (ADT): 178.5
% Heavy Trucks (of ADT) FHWA Class 5 or Greater: 2.5
Number of Lanes In Design Direction: 2
Percent of All Trucks In Design Lane (%): 100
Percent Trucks In Design Direction (%): 100
Average Initial Truck Factor (ESALs/truck): 1
Annual Truck Factor Growth Rate (%): 0
Annual Truck Volume Growth Rate (%): 4
Growth: Simple

Total Calculated Cumulative Esals: 44,986

~ 6.16 Daily

UPN										
Route										
Name	Makoshika State park Road Improvements									
Date of Run	12/18/17									

Instructions:

1 Enter design inputs into GRAY CELLS

2 A solution to the 1993 AASHTO Equation 1.1.2 in Section I-5 is obtained by iterating "**SN_{DES}**" until **"W18" = "20 Year ESAL"**.

3 The iteration can be done manually, or by using the 'Goal Seek' function in Excel. This is done by going to the **Data Tab** and selecting **What-If Analysis /Goal Seek**

4 Once the solution is found and the value for 20 Year ESAL (Row 13) is equal to the value W18 (Row 22), The '**Demand**' or required Structural Number (SN_{DES}) is given in row 21.

5 Next, In the '**Capacity**' section, enter in the typical section coefficients and thickness (units = inches)

6 The typical section is adequate if **SN_{total}** (row 39) is greater than or equal to **SN_{DES}** (row 21). Row 40 will report "DESIGN OK" if the typical section is structurally adequate, and "ERROR" if the typical is underdesigned.

= Input
= Calculated Value
= Match value of these two rows

Typical Section	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
Traffic	**Total Reconst**	**Existing Recl**	**Add CBC, recl**	**Recl CTB**			**16-Year Des**				
Daily ESAL	6.16	6.16	6.16	6.16			6.16				
Yearly ESAL	2248.4	2248.4	2248.4	2248.4	0	0	2248.4	0	0	0	
20 Year ESAL	44986	44986	44986	44986	0	0.00	35974.4	0	0	0	
Demand											
Note	CAC	Reclaimed	2" CBC, 8" Recl	Recl CTB 7"			Reclaimed				
Note	M_r=4500	M_r=4500	M_r=4500	M_r=4500			M_r=4500				
Reliability	75	75	75	75			75				
So	0.45	0.45	0.45	0.45			0.45				
DeltaPSI	1.7	1.7	1.7	1.7			1.7				
Mr	4500	4500	4500	4500			4500				
SN_{DES}	**2.28**	**2.28**	**2.28**	**2.28**			**2.19**				
W18	*44986*	*44986*	*44986*	*44986*	*#N/A*	*#N/A*	*35974*	*#N/A*	*#N/A*	*#N/A*	
Zr	*-0.674*	*-0.674*	*-0.674*	*-0.674*	*#N/A*	*#N/A*	*-0.674*	*#N/A*	*#N/A*	*#N/A*	
ESAL	*6*	*6*	*6*	*6*	*#N/A*	*#N/A*	*5*	*#N/A*	*#N/A*	*#N/A*	
Life	*20.0*	*20.0*	*20.0*	*20.0*	*#N/A*	*#N/A*	*20.0*	*#N/A*	*#N/A*	*#N/A*	
Capacity											
a1	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	Layer 1
D1 (in)	**3**	**3**	**3**	**3**			**3**				a1 = 0.41
SN1	1.2	1.2	1.2	1.2	0.0	0.0	1.2	0.0	0.0	0.0	
a2	**0.14**	**0.12**	**0.12**	**0.16**			**0.12**				Layer 2
m2	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	a2 = 0.14 for CAC
D2 (in)	**8.0**	**8.5**	**9.5**	**7.0**			**8.5**				a2 = 0.20 for CTB
SN2	1.1	1.0	1.1	1.1	0.0	0.0	1.0	0.0	0.0	0.0	
a3											Layer 3
m3	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	a3 = 0.07 for
D3 (in)											Special Borrow
SN3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
a4											Layer 4
m4	1	1	1	1	1	1	1	1	1	1	a4 = 0.07 for
D4 (in)											Special Borrow
SN4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Sntot = SN1+SN2+SN3+SN4	**2.29**	**2.20**	**2.31**	**2.29**	**0.00**	**0.00**	**2.20**	**0.00**	**0.00**	**0.00**	
Traffic Chk W18=20 Yr ESAL	OK	OK	OK	OK	#N/A	#N/A	OK	#N/A	#N/A	#N/A	
SN Check	OK	NG	OK	OK	NG	NG	OK	NG	NG	NG	
Design Check	**DESIGN OK**	**ERROR**	**DESIGN OK**	**DESIGN OK**	**#N/A**	**#N/A**	**DESIGN OK**	**#N/A**	**#N/A**	**#N/A**	

Layer 1 (ft)	0.25	0.25	0.25	0.25	0.00	0.00	0.25	0.00	0.00	0.00
Layer 2 (ft)	0.67	0.71	0.79	0.58	0.00	0.00	0.71	0.00	0.00	0.00
Layer 3 (ft)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Layer 4 (ft)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	0.92	0.96	1.04	0.83	0.00	0.00	0.96	0.00	0.00	0.00

Layer 1 (mm)	76	76	76	76	0	0	76	0	0	0
Layer 2 (mm)	203	216	241	178	0	0	216	0	0	0
Layer 3 (mm)	0	0	0	0	0	0	0	0	0	0
Layer 4 (mm)	0	0	0	0	0	0	0	0	0	0
Total	279	292	318	254	0	0	292	0	0	0

Appendix 2

ANALYTICAL SUMMARY REPORT

November 30, 2017

SK Geotechnical
PO Box 80190
Billings, MT 59108-0190

Work Order: B17111571

Project Name: 17-3612G

Energy Laboratories Inc Billings MT received the following 6 samples for SK Geotechnical on 11/16/2017 for analysis.

Lab ID	Client Sample ID	Collect Date	Receive Date	Matrix	Test
B17111571-001	ST-6 Base 28.58g	11/15/17 12:00	11/16/17	Soil	Sulfate-Geochemical
B17111571-002	ST-9A Base 30.15g	11/15/17 12:30	11/16/17	Soil	Same As Above
B17111571-003	ST-2 Base 31.15	11/15/17 13:00	11/16/17	Soil	Same As Above
B17111571-004	ST-9A BULK 1.5-4 Feet 146.26g	11/16/17 15:30	11/16/17	Soil	Cation Exchange Capacity Metals, NH4OAC Extractable Metals, Saturated Paste Conductivity, Saturated Paste Extract Exchangeable Sodium Percentage NH4AC Soil Extraction for CEC Ammonium Acetate Extraction Saturated Paste Extraction Sodium Adsorption Ratio Saturation Percentage Sulfate-Geochemical
B17111571-005	ST-6 BULK 1.5-4 Feet 111.91g	11/16/17 15:35	11/16/17	Soil	Cation Exchange Capacity Metals, NH4OAC Extractable Metals, Saturated Paste Conductivity, Saturated Paste Extract Exchangeable Sodium Percentage NH4AC Soil Extraction for CEC Ammonium Acetate Extraction Saturated Paste Extraction Sodium Adsorption Ratio Saturation Percentage
B17111571-006	ST-4 BULK 1-4 Feet 220.03g	11/16/17 15:40	11/16/17	Soil	Same As Above

The analyses presented in this report were performed by Energy Laboratories, Inc., 1120 S 27th St., Billings, MT 59101, unless otherwise noted. Any exceptions or problems with the analyses are noted in the Laboratory Analytical Report, the QA/QC Summary Report, or the Case Narrative.

The results as reported relate only to the item(s) submitted for testing.

If you have any questions regarding these test results, please call.

Report Approved By:

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client: SK Geotechnical
Project: 17-3612G
Report Date: 11/30/17

Lab ID: B17111571-001
Client Sample ID: ST-6 Base 28.58g
Collection Date: 11/15/17 12:00
DateReceived: 11/16/17
Matrix: Soil

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
CHEMICAL CHARACTERISTICS							
Sulfate, HCL Extractable	0.03	wt%		0.01		MTDOT	11/21/17 13:03 / srm

Lab ID: B17111571-002
Client Sample ID: ST-9A Base 30.15g
Collection Date: 11/15/17 12:30
DateReceived: 11/16/17
Matrix: Soil

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
CHEMICAL CHARACTERISTICS							
Sulfate, HCL Extractable	0.12	wt%		0.01		MTDOT	11/21/17 13:03 / srm

Lab ID: B17111571-003
Client Sample ID: ST-2 Base 31.15
Collection Date: 11/15/17 13:00
DateReceived: 11/16/17
Matrix: Soil

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
CHEMICAL CHARACTERISTICS							
Sulfate, HCL Extractable	ND	wt%		0.01		MTDOT	11/21/17 13:03 / srm

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
D - RL increased due to sample matrix.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client: SK Geotechnical
Project: 17-3612G
Report Date: 11/30/17

Lab ID: B17111571-004
Client Sample ID: ST-9A BULK 1.5-4 Feet 146.26g
Collection Date: 11/16/17 15:30
DateReceived: 11/16/17
Matrix: Soil

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
CHEMICAL CHARACTERISTICS							
Cation Exchange Capacity	22.8	meq/100g	D	0.02		SW6010B	11/29/17 17:51 / slf
SATURATED PASTE EXTRACT							
Conductivity, sat. paste	6.7	mmhos/cm		0.1		ASA10-3	11/28/17 14:17 / srm
Saturation	85.0	wt%		0.1		USDA27a	11/30/17 10:43 / srm
Calcium, sat. paste	6.63	meq/L		0.05		SW6010B	11/29/17 19:43 / slf
Magnesium, sat. paste	4.08	meq/L		0.08		SW6010B	11/29/17 19:43 / slf
Sodium, sat. paste	71.9	meq/L		0.04		SW6010B	11/29/17 19:43 / slf
Sodium Adsorption Ratio (SAR)	31.0	unitless		0.01		Calculation	11/30/17 10:43 / srm
CHEMICAL CHARACTERISTICS							
Exchangeable Magnesium Percentage	20.0	%		0.1		USDA20a	11/30/17 10:43 / srm
Sulfate, HCL Extractable	0.29	wt%		0.01		MTDOT	11/21/17 13:04 / srm
Exchangeable Sodium Percentage	31.2	%		0.1		USDA20a	11/30/17 10:43 / srm
METALS, AMMONIUM ACETATE EXTRACTABLE							
Magnesium, extractable	4.90	meq/100g		0.008		SW6010B	11/28/17 04:26 / slf
Sodium, extractable	13.2	meq/100g		0.004		SW6010B	11/28/17 04:26 / slf

Lab ID: B17111571-005
Client Sample ID: ST-6 BULK 1.5-4 Feet 111.91g
Collection Date: 11/16/17 15:35
DateReceived: 11/16/17
Matrix: Soil

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
CHEMICAL CHARACTERISTICS							
Cation Exchange Capacity	11.7	meq/100g	D	0.02		SW6010B	11/29/17 17:55 / slf
SATURATED PASTE EXTRACT							
Conductivity, sat. paste	1.3	mmhos/cm		0.1		ASA10-3	11/28/17 14:17 / srm
Saturation	31.8	wt%		0.1		USDA27a	11/30/17 10:43 / srm
Calcium, sat. paste	1.45	meq/L		0.05		SW6010B	11/29/17 19:46 / slf
Magnesium, sat. paste	1.55	meq/L		0.08		SW6010B	11/29/17 19:46 / slf
Sodium, sat. paste	13.4	meq/L		0.04		SW6010B	11/29/17 19:46 / slf
Sodium Adsorption Ratio (SAR)	11.0	unitless		0.01		Calculation	11/30/17 10:43 / srm
CHEMICAL CHARACTERISTICS							
Exchangeable Magnesium Percentage	43.6	%		0.1		USDA20a	11/30/17 10:43 / srm
Exchangeable Sodium Percentage	11.2	%		0.1		USDA20a	11/30/17 10:43 / srm
METALS, AMMONIUM ACETATE EXTRACTABLE							
Magnesium, extractable	5.16	meq/100g		0.008		SW6010B	11/28/17 04:29 / slf
Sodium, extractable	1.74	meq/100g		0.004		SW6010B	11/28/17 04:29 / slf

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
D - RL increased due to sample matrix.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client: SK Geotechnical
Project: 17-3612G
Report Date: 11/30/17

Lab ID: B17111571-006
Client Sample ID: ST-4 BULK 1-4 Feet 220.03g
Collection Date: 11/16/17 15:40
DateReceived: 11/16/17
Matrix: Soil

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
CHEMICAL CHARACTERISTICS							
Cation Exchange Capacity	14.1	meq/100g	D	0.02		SW6010B	11/29/17 18:02 / slf
SATURATED PASTE EXTRACT							
Conductivity, sat. paste	1.1	mmhos/cm		0.1		ASA10-3	11/28/17 14:17 / srm
Saturation	34.1	wt%		0.1		USDA27a	11/30/17 10:43 / srm
Calcium, sat. paste	2.98	meq/L		0.05		SW6010B	11/29/17 19:50 / slf
Magnesium, sat. paste	2.23	meq/L		0.08		SW6010B	11/29/17 19:50 / slf
Sodium, sat. paste	9.12	meq/L		0.04		SW6010B	11/29/17 19:50 / slf
Sodium Adsorption Ratio (SAR)	5.65	unitless		0.01		Calculation	11/30/17 10:43 / srm
CHEMICAL CHARACTERISTICS							
Exchangeable Magnesium Percentage	42.5	%		0.1		USDA20a	11/30/17 10:43 / srm
Exchangeable Sodium Percentage	6.6	%		0.1		USDA20a	11/30/17 10:43 / srm
METALS, AMMONIUM ACETATE EXTRACTABLE							
Magnesium, extractable	6.08	meq/100g		0.008		SW6010B	11/28/17 04:40 / slf
Sodium, extractable	1.25	meq/100g		0.004		SW6010B	11/28/17 04:40 / slf

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
D - RL increased due to sample matrix.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

QA/QC Summary Report

Prepared by Billings, MT Branch

Client: SK Geotechnical
Project: 17-3612G

Report Date: 11/30/17
Work Order: B17111571

Analyte	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: ASA10-3									Batch: 116194
Lab ID: B17111571-006A DUP	Sample Duplicate				Run: MISC-SOIL_171128A				11/28/17 14:17
Conductivity, sat. paste	1.20	mmhos/cm	0.10				6.9	30	
Lab ID: LCS-1711281417	Laboratory Control Sample				Run: MISC-SOIL_171128A				11/28/17 14:17
Conductivity, sat. paste	4.43	mmhos/cm	0.10	108	70	130			

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

QA/QC Summary Report

Prepared by Billings, MT Branch

Client: SK Geotechnical
Project: 17-3612G

Report Date: 11/30/17
Work Order: B17111571

Analyte	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: Calculation									Batch: R290947
Lab ID: B17111571-006A DUP	Sample Duplicate				Run: MISC-SOIL_171130A				11/30/17 10:43
Sodium Adsorption Ratio (SAR)	5.66	unitless	0.010				0.2	30	
Lab ID: LCS-1711301043	Laboratory Control Sample				Run: MISC-SOIL_171130A				11/30/17 10:43
Sodium Adsorption Ratio (SAR)	8.96	unitless	0.010	95	70	130			

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

QA/QC Summary Report

Prepared by Billings, MT Branch

Client: SK Geotechnical
Project: 17-3612G

Report Date: 11/30/17
Work Order: B17111571

Analyte	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: MTDOT									Batch: R290626
Lab ID: LCS	Laboratory Control Sample				Run: MISC-SOIL_171122A				11/21/17 13:01
Sulfate, HCL Extractable	0.07	wt%	0.01	96	70	130			
Lab ID: MBLK1	Method Blank				Run: MISC-SOIL_171122A				11/21/17 13:01
Sulfate, HCL Extractable	0.003	wt%							
Lab ID: B17111121-001A DUP	Sample Duplicate				Run: MISC-SOIL_171122A				11/21/17 13:02
Sulfate, HCL Extractable	0.12	wt%	0.01				3.9	30	

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

QA/QC Summary Report

Prepared by Billings, MT Branch

Client: SK Geotechnical
Project: 17-3612G

Report Date: 11/30/17
Work Order: B17111571

Analyte	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: SW6010B									Batch: 116136
Lab ID: LCS-116136	Laboratory Control Sample				Run: ICP203-B_171127A				11/28/17 04:15
Magnesium, extractable	3.42	meq/100g	0.0083	86	70	130			
Sodium, extractable	2.03	meq/100g	0.0044	85	70	130			
Lab ID: B17111571-006A DUP	Sample Duplicate				Run: ICP203-B_171127A				11/28/17 04:43
Magnesium, extractable	6.09	meq/100g	0.0083				0.2	30	
Sodium, extractable	1.25	meq/100g	0.0044				0.3	30	
Lab ID: B17111592-001AMS2	Sample Matrix Spike				Run: ICP203-B_171127A				11/28/17 04:50
Magnesium, extractable	53.9	meq/100g	0.0083	109	70	130			
Sodium, extractable	29.3	meq/100g	0.0044	116	70	130			
Method: SW6010B									Batch: 116152
Lab ID: LCS-116152	Laboratory Control Sample				Run: ICP203-B_171129A				11/29/17 17:48
Cation Exchange Capacity	14.3	meq/100g	0.087	83	50	150			
Lab ID: B17111571-005AMS2	Sample Matrix Spike				Run: ICP203-B_171129A				11/29/17 17:58
Cation Exchange Capacity	54.0	meq/100g	0.087	97	50	150			
Lab ID: B17111571-006A DUP	Sample Duplicate				Run: ICP203-B_171129A				11/29/17 18:05
Cation Exchange Capacity	14.0	meq/100g	0.087				0.9	30	
Method: SW6010B									Batch: 116194
Lab ID: LCS-116194	Laboratory Control Sample				Run: ICP203-B_171129A				11/29/17 19:01
Calcium, sat. paste	15.3	meq/L	0.050	96	70	130			
Magnesium, sat. paste	9.10	meq/L	0.082	125	70	130			
Sodium, sat. paste	31.3	meq/L	0.043	108	70	130			
Lab ID: B17111571-006A DUP	Sample Duplicate				Run: ICP203-B_171129A				11/29/17 19:53
Calcium, sat. paste	2.91	meq/L	0.050				2.5	30	
Magnesium, sat. paste	2.16	meq/L	0.082				3.1	30	
Sodium, sat. paste	9.00	meq/L	0.043				1.3	30	
Lab ID: B17111860-001AMS2	Sample Matrix Spike				Run: ICP203-B_171129A				11/29/17 20:01
Calcium, sat. paste	3.22	meq/L	0.050	105	70	130			
Magnesium, sat. paste	4.68	meq/L	0.082	109	70	130			
Sodium, sat. paste	2.52	meq/L	0.043	111	70	130			

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

QA/QC Summary Report

Prepared by Billings, MT Branch

Client: SK Geotechnical
Project: 17-3612G

Report Date: 11/30/17
Work Order: B17111571

Analyte	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: USDA20a									Batch: R290947
Lab ID: B17111571-006A DUP	Sample Duplicate				Run: MISC-SOIL_171130A				11/30/17 10:43
Exchangeable Magnesium Percentage	42.9	%	0.10						
Exchangeable Sodium Percentage	6.68	%	0.10				1.1	30	
Lab ID: LCS-1711301043	Laboratory Control Sample				Run: MISC-SOIL_171130A				11/30/17 10:43
Exchangeable Magnesium Percentage	21.6	%	0.10	84	70	130			
Exchangeable Sodium Percentage	6.20	%	0.10	73	70	130			

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

QA/QC Summary Report

Prepared by Billings, MT Branch

Client: SK Geotechnical
Project: 17-3612G

Report Date: 11/30/17
Work Order: B17111571

Analyte	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: **USDA27a**									Batch: R290947
Lab ID: **B17111571-006A DUP**	Sample Duplicate				Run: MISC-SOIL_171130A				11/30/17 10:43
Saturation	34.7	%	0.10				1.7	30	
Lab ID: **LCS-1711301043**	Laboratory Control Sample				Run: MISC-SOIL_171130A				11/30/17 10:43
Saturation	36.5	%	0.10	96	70	130			

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

Work Order Receipt Checklist

SK Geotechnical

B17111571

Login completed by: Tabitha Edwards
Date Received: 11/16/2017

Reviewed by: BL2000\cindy
Received by: rs4

Reviewed Date: 11/22/2017
Carrier name: Hand Del

Shipping container/cooler in good condition?	Yes ☐	No ☐	Not Present ☑
Custody seals intact on all shipping container(s)/cooler(s)?	Yes ☐	No ☐	Not Present ☑
Custody seals intact on all sample bottles?	Yes ☐	No ☐	Not Present ☑
Chain of custody present?	Yes ☑	No ☐	
Chain of custody signed when relinquished and received?	Yes ☑	No ☐	
Chain of custody agrees with sample labels?	Yes ☑	No ☐	
Samples in proper container/bottle?	Yes ☑	No ☐	
Sample containers intact?	Yes ☑	No ☐	
Sufficient sample volume for indicated test?	Yes ☑	No ☐	
All samples received within holding time? (Exclude analyses that are considered field parameters such as pH, DO, Res Cl, Sulfite, Ferrous Iron, etc.)	Yes ☑	No ☐	
Temp Blank received in all shipping container(s)/cooler(s)?	Yes ☐	No ☑	Not Applicable ☐
Container/Temp Blank temperature:	21.0°C No Ice		
Water - VOA vials have zero headspace?	Yes ☐	No ☐	No VOA vials submitted ☑
Water - pH acceptable upon receipt?	Yes ☐	No ☐	Not Applicable ☑

Standard Reporting Procedures:

Lab measurement of analytes considered field parameters that require analysis within 15 minutes of sampling such as pH, Dissolved Oxygen and Residual Chlorine, are qualified as being analyzed outside of recommended holding time.

Solid/soil samples are reported on a wet weight basis (as received) unless specifically indicated. If moisture corrected, data units are typically noted as –dry. For agricultural and mining soil parameters/characteristics, all samples are dried and ground prior to sample analysis.

Contact and Corrective Action Comments:

Additional sample for ST-9A BULK 1.5-4 Feet 146.26g collected 11/20/17 10:45, ST-6 BULK 1.5-4 Feet 111.91g collected 11/20/17 10:29 and ST-4 BULK 1-4 Feet 220.03g collected 11/20/17 10:20 was received on 11/20/17 by Siobhan H. Coop at 21.6°C no ice by hand delivery.

Chain of Custody and Analytical Request Record

PLEASE PRINT- Provide as much information as possible.

Company Name: SK Geotechnical Corp.	Project Name, PWS, Permit, Etc. 17-3612G	Sample Origin State: MT	EPA/State Compliance: Yes ☐ No ☒
Report Mail Address: jdebar@SKgeotechnical.com	Contact Name: Joe DeBar; Phone/Fax: 406-652-3930; Email: jdebar@SKgeotechnical.com		Sampler: (Please Print) Drill crew
Invoice Address: billings@SKgeotechnical.com	Invoice Contact & Phone: Kim Raynor 406-652-3930	Purchase Order:	Quote/Bottle Order:

Special Report/Formats – ELI must be notified prior to sample submittal for the following:

☐ DW ☐ A2LA
☐ GSA ☐ EDD/EDT (Electronic Data)
☐ POTW/WWTP Format: _____
☐ State: _____ ☐ LEVEL IV
☐ Other: _____ ☐ NELAC

Number of Containers
Sample Type: A W S V B O
Air Water Soils/Solids
Vegetation Bioassay Other

SAMPLE IDENTIFICATION (Name, Location, Interval, etc.)	Collection Date	Collection Time	MATRIX	MT-232 Sulfate	Exchangeable Sodium & CEC	ESP, ESP+ EMgP	SAR, SP	Total Dissolved Solids	SEE ATTACHED	Normal Turnaround (TAT)
ST-6 Base 28.58g	11/15/17	12:00pm	1 bag soil	X						
ST-9A Base 30.15g	11/15/17	12:30 pm	1 bag soil	X						
ST-2 Base 31.15g	11/15/17	1:00 pm	1 bag soil	X						
ST-9A BULK 1.5'-4' 146.26g	11/16/17	3:30 pm	1 bag soil	X		X	X			
ST-6 BULK 1.5'-4' 111.91g	11/16/17	3:35 pm	1 bag soil			X	X			
ST-4 BULK 1'-4' 220.03g	11/16/17	3:40 pm	1 bag soil			X	X			

R U S H

Contact ELI prior to **RUSH** sample submittal for charges and scheduling – See Instruction Page

Comments:
Left msg for Joe DeBar for more volume on bulk samples.
SE 11/16/17

Shipped by:

Cooler ID(s):

Receipt Temp _____ °C

On Ice: Yes No

Custody Seal Y N
Intact Y N
Signature Match Y N

B1711571-001
002
003
004
005 ~~Separate worksheet~~
006 1

~~Sulfate only on this worksheet~~ AE 11-20

LABEL ALL CONTAINERS WITH UNIQUE ID

Custody Record MUST be Signed

Relinquished by (print)	Date/Time	Signature	Received by (print)	Date/Time	Signature
Mackenzie Wilkinson	11/16/17 16:44	Mackenzie Wilkinson			
Relinquished by (print)	Date/Time	Signature	Received by (print)	Date/Time	Signature
			Received by Laboratory:	Date/Time: 11/16/17 16:44	Signature:

Sample Disposal: Return to Client: _____ Lab Disposal: _____

In certain circumstances, samples submitted to Energy Laboratories, Inc. may be subcontracted to other certified laboratories in order to complete the analysis requested. This serves as notice of this possibility. All sub-contract data will be clearly notated on your analytical report.
Visit our web site at www.energylab.com for additional information, downloadable fee schedule, forms, and links.

Chain of Custody and Analytical Request Record

Page _____ of _____

PLEASE PRINT (Provide as much information as possible.)

Company Name:	Project Name, PWS, Permit, Etc.	Sample Origin	EPA/State Compliance:
SK - GEO	3612G	State:	Yes ☐ No ☐
Report Mail Address:	**Contact Name:** Phone/Fax:	**Email:**	**Sampler: (Please Print)**
Invoice Address:	**Invoice Contact & Phone:**	**Purchase Order:**	**Quote/Bottle Order:**

Special Report/Formats:

☐ DW ☐ EDD/EDT (Electronic Data)
☐ POTW/WWTP **Format:**_____
☐ State: _____ ☐ LEVEL IV
☐ Other: _____ ☐ NELAC

ANALYSIS REQUESTED

Number of Containers
Sample Type: A Air W Water S Soils/Solids V Vegetation B Bioassay O Other DW - Drinking Water

SEE ATTACHED

Standard Turnaround (TAT)

R U S H

Contact ELI prior to **RUSH** sample submittal for charges and scheduling – See Instruction Page

Comments: Additional material requested by sheri for salt tests

Shipped by:

Cooler ID(s):

Receipt Temp _____ °C

On Ice: Y N

Custody Seal On Bottle Y N On Cooler Y N

Intact Y N

Signature Match Y N

	SAMPLE IDENTIFICATION (Name, Location, Interval, etc.)	Collection Date	Collection Time	MATRIX
1	ST-4	11/20/17	10:20 AM	zip loc
2	ST-6	11/20/17	10:29	"
3	ST-9A	11/20/17	10:45	"
4				
5				
6				
7				
8				
9				
10				

LABORATORY USE ONLY

B17111571-006
005
004

Custody Record MUST be Signed

	Relinquished by (print):	Date/Time:	Signature:	Received by (print):	Date/Time:	Signature:
1	Mackenzie Wilkinson	11/20/17 11:28	Mackenzie Wilkinson			
2						

Sample Disposal: Return to Client: _____ Lab Disposal: _____

Received by Laboratory: Date/Time: 11/20/17 1128

In certain circumstances, samples submitted to Energy Laboratories, Inc. may be subcontracted to other certified laboratories in order to complete the analysis requested.
This serves as notice of this possibility. All sub-contract data will be clearly notated on your analytical report.
Visit our web site at www.energylab.com for additional information, downloadable fee schedule, forms, and links.

ANALYTICAL SUMMARY REPORT

November 15, 2017

SK Geotechnical
PO Box 80190
Billings, MT 59108-0190

Work Order: B17110904

Project Name: 17-3612G

Energy Laboratories Inc Billings MT received the following 6 samples for SK Geotechnical on 11/10/2017 for analysis.

Lab ID	Client Sample ID	Collect Date	Receive Date	Matrix	Test
B17110904-001	17-3612, ST-6 BB	11/10/17 12:00	11/10/17	Soil	Sulfate-Geochemical
B17110904-002	17-3612, ST-1 BB	11/10/17 12:30	11/10/17	Soil	Same As Above
B17110904-003	17-3612, ST-9A BB	11/10/17 13:00	11/10/17	Soil	Same As Above
B17110904-004	17-3612, ST-7 BB	11/10/17 13:30	11/10/17	Soil	Same As Above
B17110904-005	17-3612, ST-3A BB	11/10/17 13:31	11/10/17	Soil	Same As Above
B17110904-006	17-3612, ST-4 BB	11/10/17 13:32	11/10/17	Soil	Same As Above

The analyses presented in this report were performed by Energy Laboratories, Inc., 1120 S 27th St., Billings, MT 59101, unless otherwise noted. Any exceptions or problems with the analyses are noted in the Laboratory Analytical Report, the QA/QC Summary Report, or the Case Narrative.

The results as reported relate only to the item(s) submitted for testing.

If you have any questions regarding these test results, please call.

Report Approved By:

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client: SK Geotechnical
Project: 17-3612G
Report Date: 11/15/17

Lab ID: B17110904-001
Client Sample ID: 17-3612, ST-6 BB
Collection Date: 11/10/17 12:00
DateReceived: 11/10/17
Matrix: Soil

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
CHEMICAL CHARACTERISTICS							
Sulfate, HCL Extractable	ND	wt%		0.01		MTDOT	11/14/17 09:34 / srm

Lab ID: B17110904-002
Client Sample ID: 17-3612, ST-1 BB
Collection Date: 11/10/17 12:30
DateReceived: 11/10/17
Matrix: Soil

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
CHEMICAL CHARACTERISTICS							
Sulfate, HCL Extractable	ND	wt%		0.01		MTDOT	11/14/17 09:34 / srm

Lab ID: B17110904-003
Client Sample ID: 17-3612, ST-9A BB
Collection Date: 11/10/17 13:00
DateReceived: 11/10/17
Matrix: Soil

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
CHEMICAL CHARACTERISTICS							
Sulfate, HCL Extractable	0.30	wt%		0.01		MTDOT	11/14/17 09:34 / srm

Lab ID: B17110904-004
Client Sample ID: 17-3612, ST-7 BB
Collection Date: 11/10/17 13:30
DateReceived: 11/10/17
Matrix: Soil

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
CHEMICAL CHARACTERISTICS							
Sulfate, HCL Extractable	0.19	wt%		0.01		MTDOT	11/14/17 09:34 / srm

Lab ID: B17110904-005
Client Sample ID: 17-3612, ST-3A BB
Collection Date: 11/10/17 13:31
DateReceived: 11/10/17
Matrix: Soil

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
CHEMICAL CHARACTERISTICS							
Sulfate, HCL Extractable	0.03	wt%		0.01		MTDOT	11/14/17 09:35 / srm

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client: SK Geotechnical
Project: 17-3612G
Report Date: 11/15/17

Lab ID: B17110904-006
Client Sample ID: 17-3612, ST-4 BB
Collection Date: 11/10/17 13:32
DateReceived: 11/10/17
Matrix: Soil

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
CHEMICAL CHARACTERISTICS							
Sulfate, HCL Extractable	ND	wt%		0.01		MTDOT	11/14/17 09:35 / srm

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

QA/QC Summary Report

Prepared by Billings, MT Branch

Client: SK Geotechnical
Project: 17-3612G

Report Date: 11/15/17
Work Order: B17110904

Analyte	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: MTDOT									Batch: R290204
Lab ID: LCS	Laboratory Control Sample				Run: MISC-SOIL_171115A				11/14/17 09:32
Sulfate, HCL Extractable	0.08	wt%	0.01	115	70	130			
Lab ID: MBLK1	Method Blank				Run: MISC-SOIL_171115A				11/14/17 09:32
Sulfate, HCL Extractable	ND	wt%							
Lab ID: B17110904-006A DUP	Sample Duplicate				Run: MISC-SOIL_171115A				11/14/17 09:35
Sulfate, HCL Extractable	ND	wt%	0.01					30	

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

Work Order Receipt Checklist

SK Geotechnical

B17110904

Login completed by: Siobhan H. Coop
Date Received: 11/10/2017
Reviewed by: BL2000\tedwards
Received by: shc
Reviewed Date: 11/14/2017
Carrier name: Hand Del

Shipping container/cooler in good condition?	Yes ☐	No ☐	Not Present ☑
Custody seals intact on all shipping container(s)/cooler(s)?	Yes ☐	No ☐	Not Present ☑
Custody seals intact on all sample bottles?	Yes ☐	No ☐	Not Present ☑
Chain of custody present?	Yes ☑	No ☐	
Chain of custody signed when relinquished and received?	Yes ☑	No ☐	
Chain of custody agrees with sample labels?	Yes ☑	No ☐	
Samples in proper container/bottle?	Yes ☑	No ☐	
Sample containers intact?	Yes ☑	No ☐	
Sufficient sample volume for indicated test?	Yes ☑	No ☐	
All samples received within holding time? (Exclude analyses that are considered field parameters such as pH, DO, Res Cl, Sulfite, Ferrous Iron, etc.)	Yes ☑	No ☐	
Temp Blank received in all shipping container(s)/cooler(s)?	Yes ☐	No ☑	Not Applicable ☐
Container/Temp Blank temperature:	20.4°C No Ice		
Water - VOA vials have zero headspace?	Yes ☐	No ☐	No VOA vials submitted ☑
Water - pH acceptable upon receipt?	Yes ☐	No ☐	Not Applicable ☑

Standard Reporting Procedures:

Lab measurement of analytes considered field parameters that require analysis within 15 minutes of sampling such as pH, Dissolved Oxygen and Residual Chlorine, are qualified as being analyzed outside of recommended holding time.

Solid/soil samples are reported on a wet weight basis (as received) unless specifically indicated. If moisture corrected, data units are typically noted as –dry. For agricultural and mining soil parameters/characteristics, all samples are dried and ground prior to sample analysis.

Contact and Corrective Action Comments:

The Project has been changed from 17-3549S to 17-3612G as requested by email from Joe DeBar.

Chain of Custody and Analytical Request Record

PLEASE PRINT- Provide as much information as possible.

Company Name: SK Geotechnical Corp.	Project Name, PWS, Permit, Etc. 17-3549S	Sample Origin State: MT	EPA/State Compliance: Yes ☐ No ☒
Report Mail Address: jdebar@SKgeotechnical.com	Contact Name: Joe DeBar — Phone/Fax: 406-652-3930 — Email: jdebar@SKgeotechnical.com		Sampler: (Please Print) Drill crew
Invoice Address: billings@SKgeotechnical.com	Invoice Contact & Phone: Kim Raynor 406-652-3930	Purchase Order:	Quote/Bottle Order:

Special Report/Formats – ELI must be notified prior to sample submittal for the following:

☐ DW ☐ A2LA
☐ GSA ☐ EDD/EDT (Electronic Data) Format: _____
☐ POTW/WWTP ☐ LEVEL IV
☐ State: _____ ☐ NELAC
☐ Other: _____

Number of Containers
Sample Type: A Air W Water S Soils/Solids V Vegetation B Bioassay O Other

SAMPLE IDENTIFICATION (Name, Location, Interval, etc.)	Collection Date	Collection Time	MATRIX	MT-232 Sulfate	SEE ATTACHED	Normal Turnaround (TAT)	RUSH	
17-3612, ST-6 BB	11/10/17	12:00pm	1 bag soil	X			X	B1711041-001
17-3612, ST - 1 BB	11/10/17	12:30 pm	1 bag soil	X			X	-002
17-3612, ST- 9A BB	11/10/17	1:00 pm	1 bag soil	X			X	-003
17-3612, ST-7 BB	11/10/17	1:30 pm	1 bag soil	X			X	-004
17-3612, ST-3A BB	11/10/17	1:31 pm	1 bag soil	X			X	-005
17-3612, ST-4 BB	11/10/17	1:32 pm	1 bag soil	X			X	-006

Contact ELI prior to **RUSH** sample submittal for charges and scheduling – See Instruction Page

Comments:

Shipped by:

Cooler ID(s):

Receipt Temp _____ °C

On Ice: Yes No

Custody Seal Y N
Intact Y N
Signature Match Y N

LABORATORY USE ONLY

Custody Record MUST be Signed

Relinquished by (print): Dustin Hutchison	Date/Time: 14:46 11/10/17	Signature:	Received by (print):	Date/Time:	Signature:
Relinquished by (print):	Date/Time:	Signature:	Received by (print):	Date/Time:	Signature:
Sample Disposal: Return to Client: _____ Lab Disposal: _____			Received by Laboratory:	Date/Time: 11/10/17 1446	Signature:

In certain circumstances, samples submitted to Energy Laboratories, Inc. may be subcontracted to other certified laboratories in order to complete the analysis requested.
This serves as notice of this possibility. All sub-contract data will be clearly notated on your analytical report.
Visit our web site at www.energylab.com for additional information downloadable fee schedule, forms, and links.

Appendix 3

2511 Holman Avenue
P. O. Box 80190
Billings, Montana 59108-0190
p: 406.652.3930; f: 406.652.3944
www.skgeotechnical.com

Classification of Dispersive Clay Soils

Date: December 8, 2017

Project: **17-3612G Geotechnical Evaluation**
Makoshika State Park
Glendive, Montana

Client: Mr. Robert Morton
Robert Peccia & Associates
P. O. Box 5653
Helena, Montana 59604-5653

Copies:

Sampled By: GTS/SK **Received:** 11/13/17 **Tests By:** RQ,MF/SK

VISUAL CLASSIFICATION

On-site soils visually classify as erodable, dispersive, and self-mulching, with general evidence of sloughing, washout, and collapse. Pavements show aligator cracking due to subgrade settlement. Surface waters are typically turbid. Exposed surfaces exhibit evidence of external erosion, including rill, gully, stream and channel erosion. Internal erosion, through cracks and underground channels, is also assumed to be a potential source of piping, tunnelling, and sinkholes. Please refer to field photos for additional detail.

PINHOLE DISPERSION, ASTM D4647 Method A (remolded to ASTM D698 at native moisture)

			Maximum			Pinhole	
Sample Location	Class	Native Moisture, %	Pressure (mm water)	Flow (ml/s)	Discharge Color	Eroded Diam (mm)	Dispersion Category
ST-4 1-4'	Sandy CL	16.8	1020	3.12	barely	1.05	ND2
ST-6 1½-4'	CL w/Sand	18.9	1020	0.60	clear	1.02	ND1
ST-9A 1½-4'	CH w/Sand	20.4	50	1.07	mod. dark	1.84	D2

TABLE 1 Criteria for Evaluating Pinhole Test Results[A]

Dispersive Classification[B]	Head, mm	Test time for given head, min.	Final flow rate through specimen, mL/s	Cloudiness of flow at end of test		Hole size after test, mm
				from side	from top	
D1 ST-9A	50	5	1.0–1.4	dark	very dark	≥2.0
D2 ST-9A	50	10	1.0–1.4	moderately dark	dark	>1.5
ND4	50	10	0.8–1.0	slightly dark	moderately dark	≤1.5
ND3	180	5	1.4–2.7	barely visible	slightly dark	≥1.5
ST-4	380	5	1.8–3.2			
ND2 ST-4	1020	5	>3.0	clear	barely	<1.5
ND1 ST-6	1020	5	≤3.0	perfectly clear	perfectly clear	1.0
			Method B			
D	50	10	...	slightly dark to dark	very dark to moderately dark	≥1.5
SD	180–380	5	...	barely visible	slightly dark	≥1.5
ND	380	5	...	clear	barely visible to clear	<1.5

[A]For criteria for Method C, see Fig. 8.
[B]Criteria for Method A adapted from the work by Wilson **(14)**.
[C] Dispersive—D1, D2.
Moderately to Slightly Dispersive—ND4, ND3.
Nondispersive—ND2, ND1.

Joe B. DeBar, PE, Materials Lab Manager

2511 Holman Avenue
P. O. Box 80190
Billings, Montana 59108-0190
p: 406.652.3930; f: 406.652.3944
www.skgeotechnical.com

Classification of Dispersive Clay Soils

Date: December 8, 2017

Project: **17-3612G Geotechnical Evaluation**
Makoshika State Park
Glendive, Montana

Client: Mr. Robert Morton
Robert Peccia & Associates
P. O. Box 5653
Helena, Montana 59604-5653

Copies:

Sampled By: GTS/SK **Received:** 11/13/17 **Tests By:** RQ,MF/SK

CRUMB TEST, ASTM D6572

Sample Location:	ST-4 1-4'	ST-6 1½-4'	ST-9A 1½-4'
Classification:	Sandy CL	CL w/Sand	CH w/Sand
Grade (1..4) *	Grade 3	Grade 4	Grade 3 to 4
Dispersion Category:	Moderate	Sever	Moderate to Sever

Joe B. DeBar, PE, Materials Lab Manager

2511 Holman Avenue
P. O. Box 80190
Billings, Montana 59108-0190
p: 406.652.3930; f: 406.652.3944
www.skgeotechnical.com

Classification of Dispersive Clay Soils

Date: December 8, 2017

Project: **17-3612G Geotechnical Evaluation**
Makoshika State Park
Glendive, Montana

Client: Mr. Robert Morton
Robert Peccia & Associates
P. O. Box 5653
Helena, Montana 59604-5653

Copies:

Sampled By: GTS/SK **Received:** 11/13/17 **Tests By:** RQ,MF/SK

DOUBLE HYDROMETER, ASTM D4221

Sample Location	Class	ASTM D4221 % Passing 5µm	ASTM D422 % Passing 5µm	Dispersion Ratio	Dispersion Category
ST-4 1-4'	Sandy CL	15.4	24.8	62	>50, Dispersive
ST-6 1½-4'	CL w/Sand	12.2	20.3	60	>50, Dispersive
ST-9A 1½-4'	CH w/Sand	12.8	38.7	33	30-50, Intermediate

Joe B. DeBar, PE, Materials Lab Manager

2511 Holman Avenue
P. O. Box 80190
Billings, Montana 59108-0190
p: 406.652.3930; f: 406.652.3944
www.skgeotechnical.com

Classification of Dispersive Clay Soils

Date: December 8, 2017

Project: **17-3612G Geotechnical Evaluation**
Makoshika State Park
Glendive, Montana

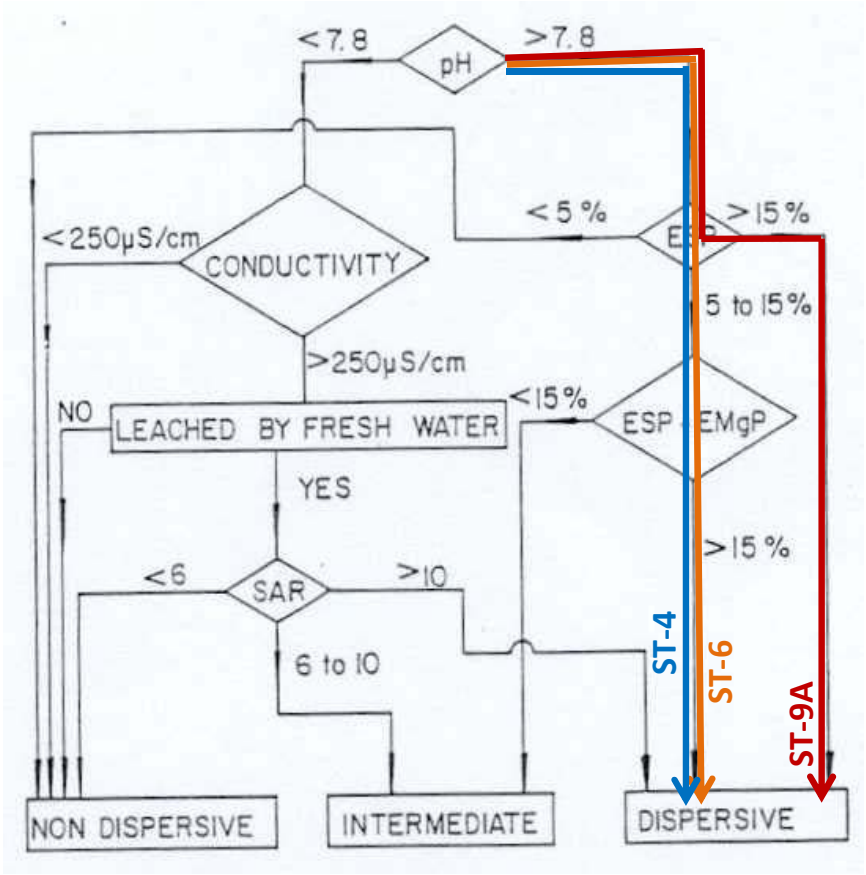
Client: Mr. Robert Morton
Robert Peccia & Associates
P. O. Box 5653
Helena, Montana 59604-5653

Copies:

ANALYTIC SALTS, USDA20a

Sample Location	Class	pH	ESP,%	ESP+ EMgP,%	SAR	Dispersion Category per ESP only	per ESP+EMgP
ST-4 1-4 '	Sandy CL	8.09	6.6	49.1	5.65	6-10, Slight	Dispersive
ST-6 1½-4 '	CL w/Sand	8.46	11.2	54.8	11.0	10-15, Moderate	Dispersive
ST-9A 1½-4 '	CH w/Sand	7.82	31.2	51.2	31.0	>15, High	Dispersive

Chemical Evaluation to determine Dispersive clays (Harmse, 1980)



Joe B. DeBar, PE, Materials Lab Manager

2511 Holman Avenue
P. O. Box 80190
Billings, Montana 59108-0190
p: 406.652.3930; f: 406.652.3944
www.skgeotechnical.com

Classification of Dispersive Clay Soils

Date: December 8, 2017

Project: **17-3612G Geotechnical Evaluation**
Makoshika State Park
Glendive, Montana

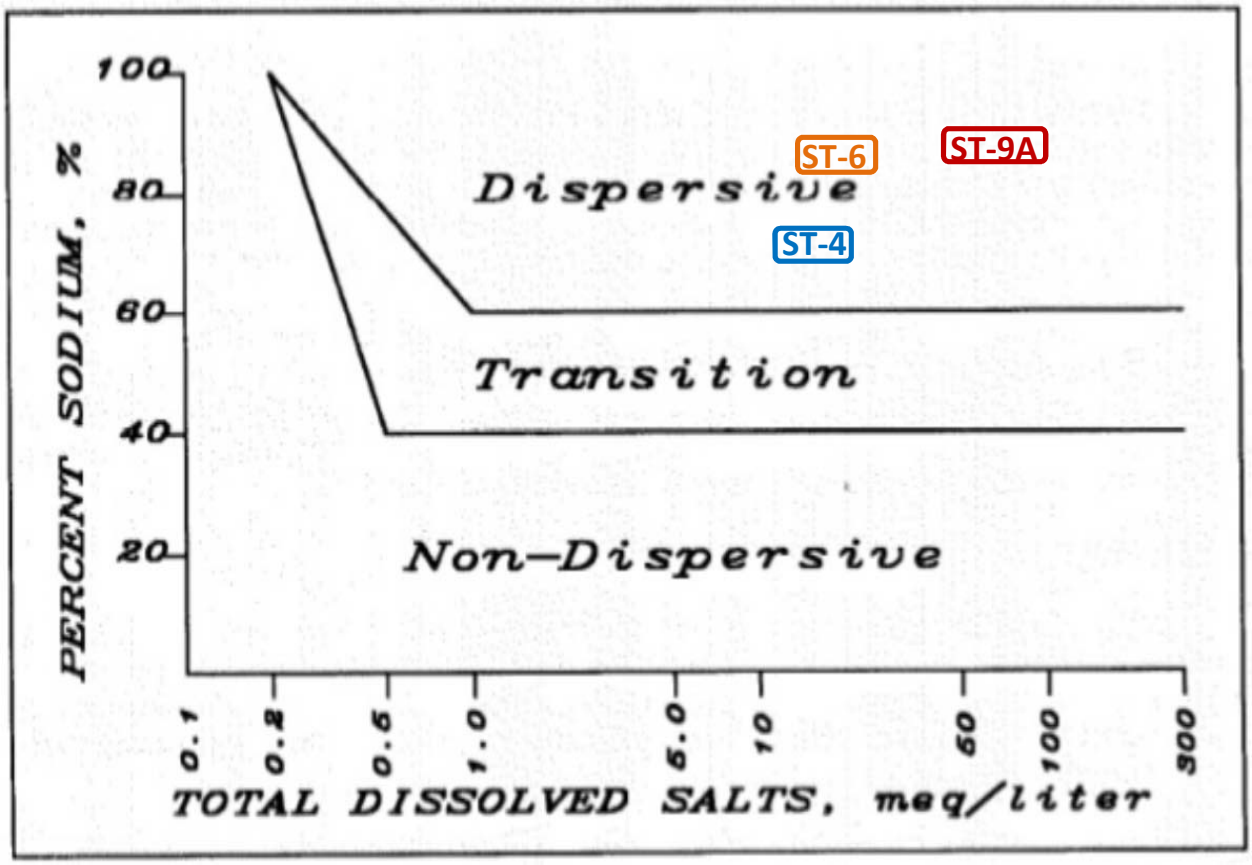
Client: Mr. Robert Morton
Robert Peccia & Associates
P. O. Box 5653
Helena, Montana 59604-5653

Copies:

ANALYTIC SALTS, SW6010B

Sample Location	Class	Concentration, meq/L Ca	Mg	Na	Total	Sodium, % wt	Dispersion Category
ST-4 1-4 '	Sandy CL	2.98	2.23	9.12	14.3	71	Dispersive
ST-6 1½-4 '	CL w/Sand	1.45	1.55	13.4	16.4	87	Dispersive
ST-9A 1½-4 '	CH w/Sand	6.63	4.08	71.9	82.6	90	Dispersive

Relationship between dispersion and soil pore water chemistry, based on pinhole erosion tests and experience with erosion in nature (Sherard et al., 1977)



Joe B. DeBar, PE, Materials Lab Manager

2511 Holman Avenue
P. O. Box 80190
Billings, Montana 59108-0190
p: 406.652.3930; f: 406.652.3944
www.skgeotechnical.com

Classification of Dispersive Clay Soils

Date: December 8, 2017

Project: **17-3612G Geotechnical Evaluation**
Makoshika State Park
Glendive, Montana

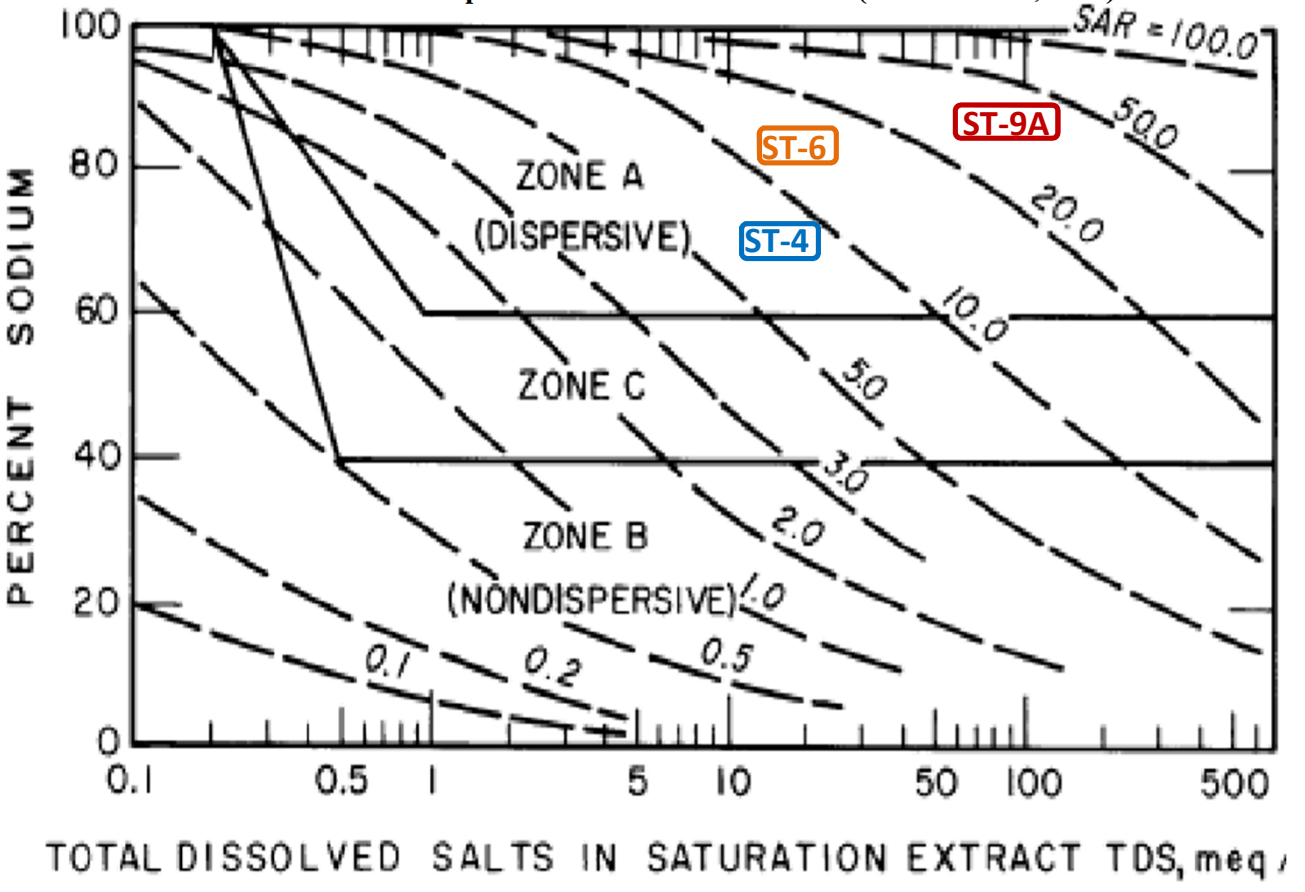
Client: Mr. Robert Morton
Robert Peccia & Associates
P. O. Box 5653
Helena, Montana 59604-5653

Copies:

ANALYTIC SALTS, SW6010B

Sample Location	Class	Concentration, meq/L Ca	Mg	Na	Total	Sodium, % wt	Dispersion Category
ST-4 1-4 '	Sandy CL	2.98	2.23	9.12	14.3	71	Dispersive
ST-6 1½-4 '	CL w/Sand	1.45	1.55	13.4	16.4	87	Dispersive
ST-9A 1½-4 '	CH w/Sand	6.63	4.08	71.9	82.6	90	Dispersive

Relationship between dispersion and soil pore water chemistry, based on pinhole erosion tests and experience with erosion in nature (Sherard et al., 1977)



Joe B. DeBar, PE, Materials Lab Manager

SK GEOTECHNICAL

2511 Holman Avenue
P. O. Box 80190
Billings, Montana 59108-0190
p: 406.652.3930; f: 406.652.3944
www.skgeotechnical.com

April 10, 2018 Project 17-3612G

Mr. Bob Morton
Robert Peccia & Associates, Inc.
Via Email: bobm@rpa-hln.com

Dear Bob:

Re: FDR with CTB Mix Design, Makoshika State Park Road Improvements, Glendive, Montana

Using samples of existing asphalt pavement and base course associated with full-depth recycling (FDR), a cement treated base (CTB) mix design has been completed for the Makoshika State Park Road Improvements project. This mix design was performed in accordance with the Portland Cement Association's Soil-Cement Laboratory Handbook (EB052.07S, 1992) and applicable ASTM, AASHTO, and MDT test methods. Analyses included sulfate concentration, grain size distribution (gradation), moisture-density relations (Proctor), strength correlations (unconfined compression), wet-dry cycles, freeze-thaw cycles, and abrasion loss.

From field borings, the average blend expected from pulverizing the existing section to a depth of 8 1/2 inches will be approximately 62 1/2 percent aggregate base and 37 1/2 percent recycled asphalt product (RAP) by dry weight. This blend was held constant in each lab test. Moisture content was varied for moisture-density curves, and cement content was varied for strength and abrasion tests. Sulfate testing indicated a manageable concentration of up to 0.12 percent in the pulverized layer. Type I/II cement was used for the FDR with CTB mix design.

A structural layer coefficient of 0.16 was assumed for the CTB, which corresponds to a 7-day compressive strength of 700 pounds per square inch (psi). PCA EB052 Figure 39 was used to determine starting experimental cement content. Based on gradation and Proctor results, strength cylinders were mixed at 5, 7, 9, 11, and 13 percent cement by dry weight, and compacted to 98 percent of the Proctor maximum dry density at optimum moisture content. Page 2 of the attached plots compressive strength versus cement content. By linear interpolation, a cement content of approximately 11.0 percent by dry weight will meet the required minimum compressive strength and is recommended for the project. Hydrated, slurry cement rather than powdered cement is recommended due to potential windy conditions during recycling and mixing. Cement content can vary slightly based on field conditions and testing, and is a function of gradation, silt and clay content, and quality of recycled materials. Pulverized material may vary from drilled geotechnical samples.

Wet-dry and freeze-thaw cycles were performed on samples with 5 percent and 9 percent cement. During these cycles, samples are measured for shrink/swell, moisture, and abrasion loss. Results indicate a slight shrinkage (0.35 to 0.5 percent), a moderate moisture gain (1 to 3 percent), and slight abrasion loss (2.4 to 4.3 percent). In wet-dry abrasion, both cement contents lost 4.3 percent by weight. In freeze-thaw abrasion, 5 and 9 percent cement contents lost 3.6 and 2.4 percent, respectively, well below the maximum loss of 14 percent, specified in MDT Sec 304.02.5.

Research indicates that underdesigned cement content in many CTB materials jeopardizes design life, as it introduces higher moisture cycles and potential shrink/swell, without the strength to manage those cycles and internal stresses. The correct cement content yields enough strength to support traffic and provides the required material durability. During construction, uniform blending and consistent, high compaction are key to realizing the full potential strength and durability of FDR with CTB. Best practices also include appropriate curing and microcracking. FDR with CTB requires specialized construction methods, and we recommend careful selection of qualified contractors for the project, followed up with full-time inspection of construction means and methods, backed by quality control field and lab testing by an experienced, accredited engineering materials lab.

Sincerely,

Joe B. DeBar, PE
Materials Testing Manager

Gregory T. Staffileno, PE
Reviewing Engineer

Attached:
CTB Mix Design Plots

CEMENT TREATED BASE (CTB) MIX DESIGN

PCA Soil-Cement Laboratory Handbook, EB052, 1992,

MT-202 Gradations

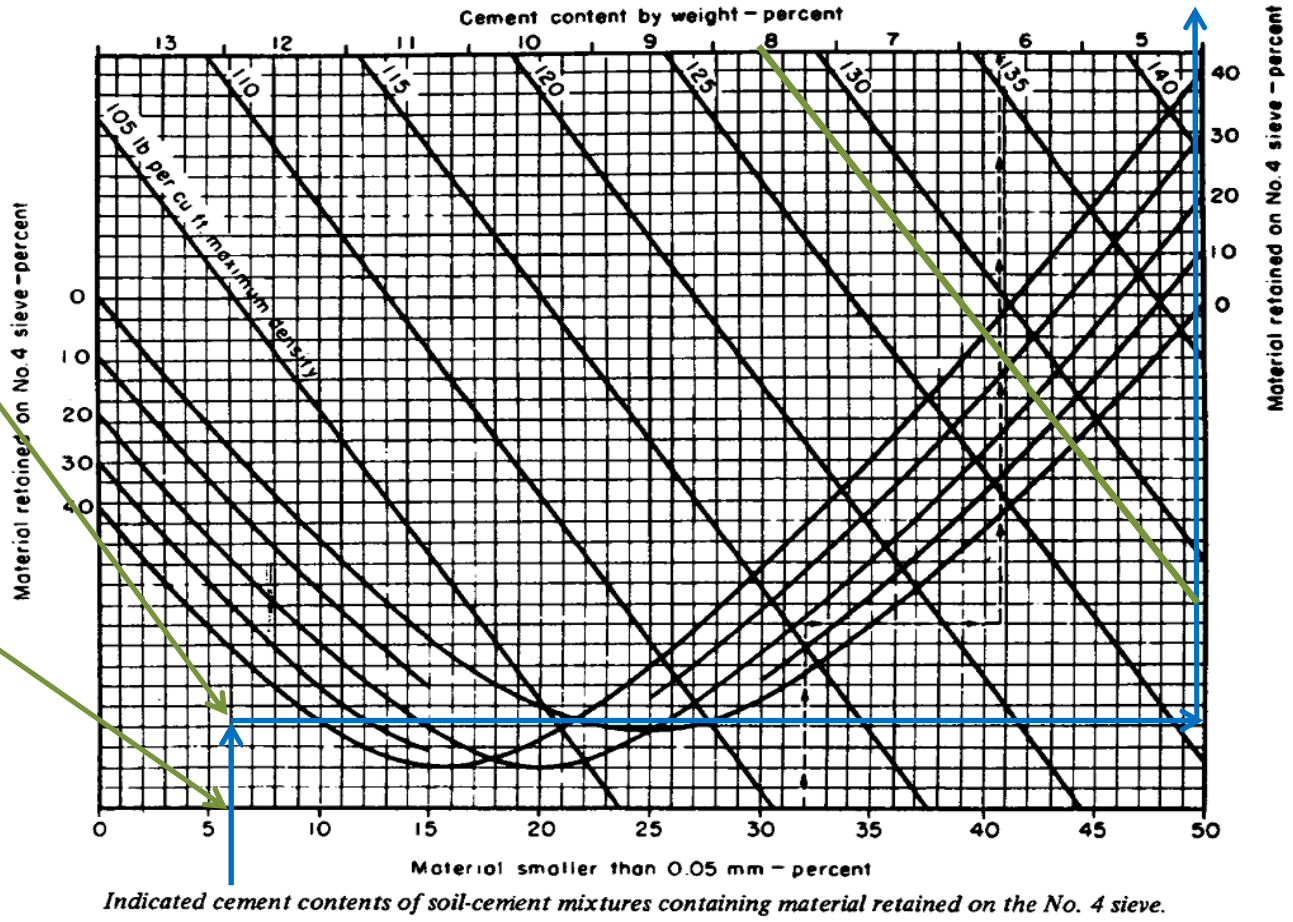
Sieve Standard (mm)	Existing Agg Base	62½Agg 37½RAP Blend	Ex-tracted Blend
3" (75)	100	100	100
1-1/2" (37.5)	100	99	100
1" (25.0)	100	96	100
3/4" (19.0)	100	93	100
1/2" (12.5)	88	82	90
3/8" (9.5)	77	71	82
#4 (4.75)	59	51	64
#10 (2)	46	35	48
#20 (.85)	39	26	38
#40 (.425)	34	22	31
#80 (.18)	15	10	15
#100 (.15)	12	8	13
#200 (.075)	6.3	4.4	7.6
.05mm	4.8	3.5	6.0
MT-208 LL,PI	NP		
MT-213 SE	NT		
MT-232 SO_4 %	0.02	(see geotech report)	

MT-210 Standard Proctor, Fine Portion:

Max Dens, pcf	128.4
Opt moist, %	6.9

MT-216 Avg. Comp. Strength, psi vs. Portland Cement, % at 98% Standard Proctor (MT-210)

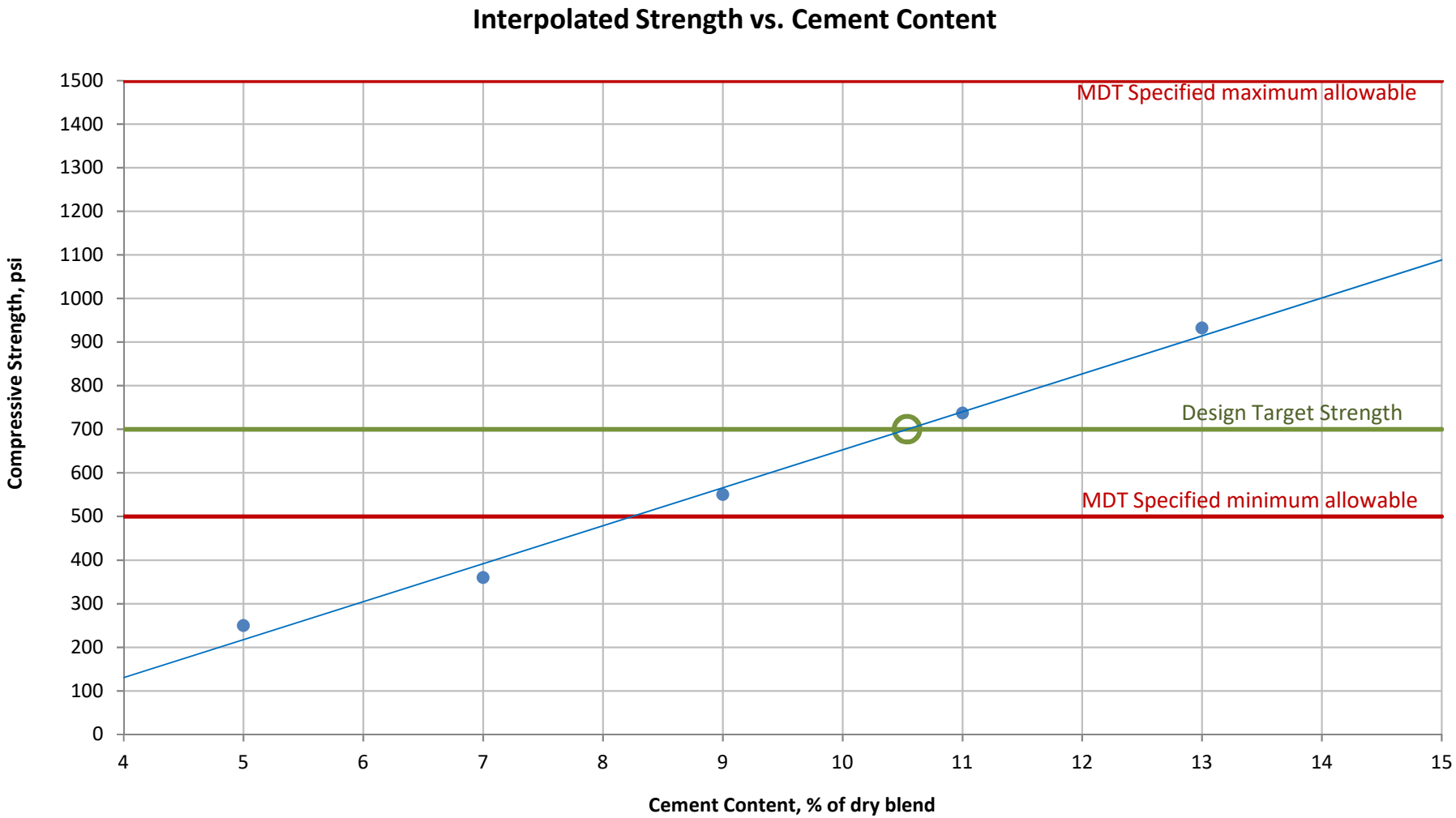
Strength, psi	933	737	700	550	360	250
cement, %	13	11	10.5	9	7	5



Indicated cement contents of soil-cement mixtures containing material retained on the No. 4 sieve.

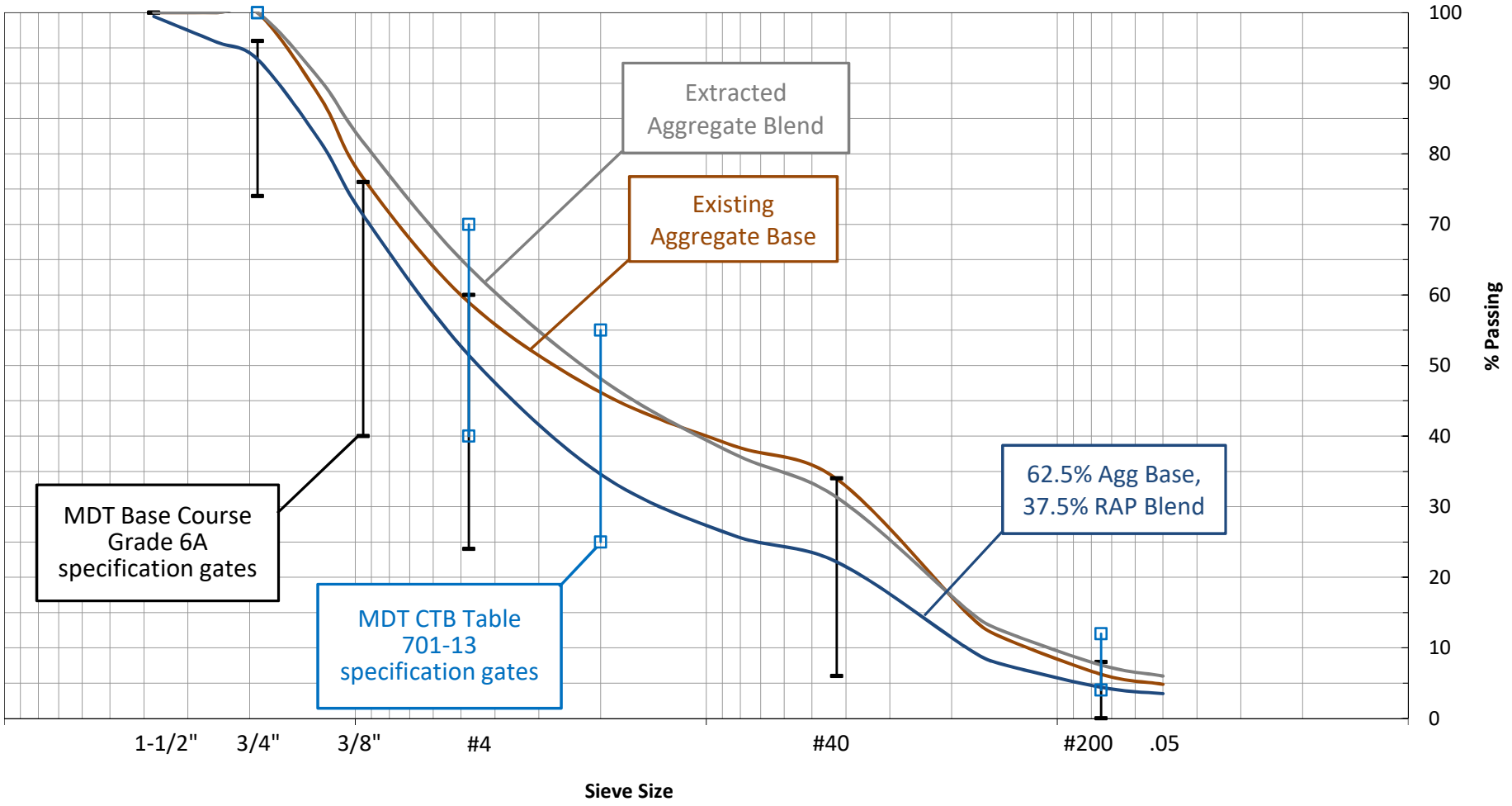
CEMENT TREATED BASE (CTB) MIX DESIGN

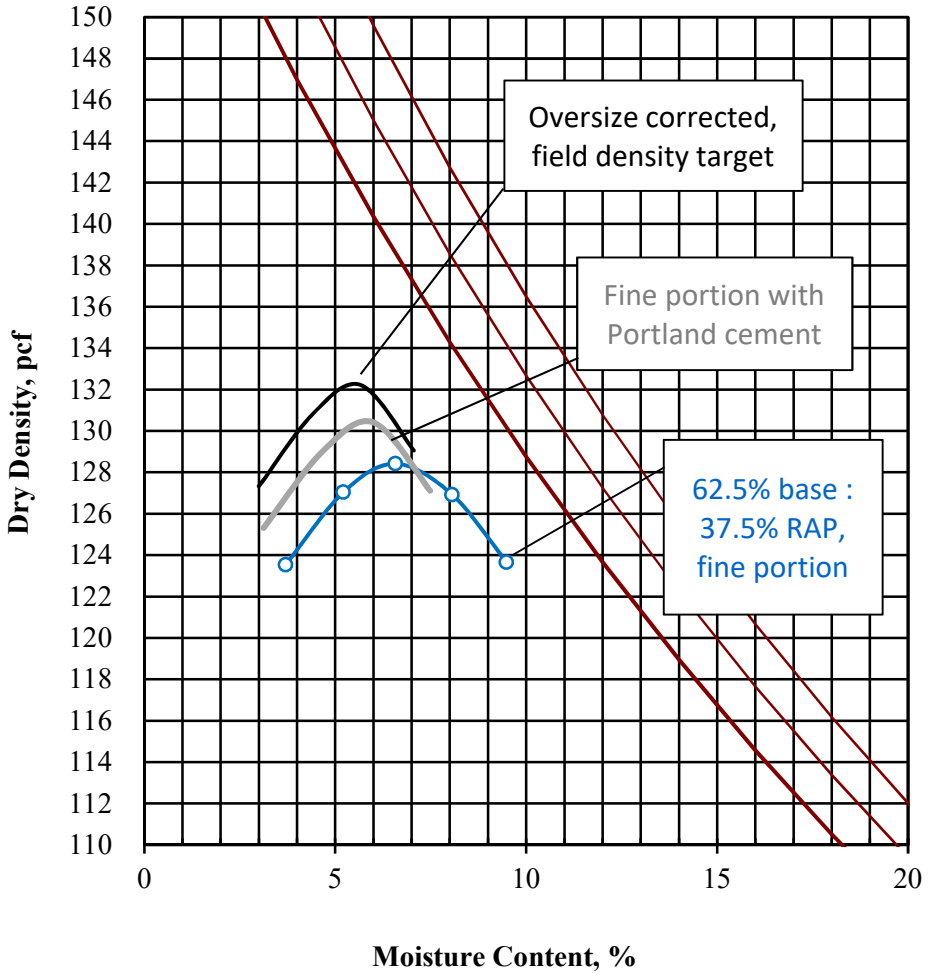
PCA Soil-Cement Laboratory Handbook, EB052, 1992,



CEMENT TREATED BASE (CTB) MIX DESIGN

PCA Soil-Cement Laboratory Handbook, EB052, 1992,





ASTM D 4718 Oversize Correction

Maximum Dry Density, pcf	*Optimum Moisture Content %*
130.3	*6.5*

ASTM C 127

Coarse Specific Gravity = 2.580

Absorption = 1.35%

Fine Portion
MT-210-08 Method D

Maximum Dry Density, pcf	Optimum Moisture Content %
128.4	6.9

Rammer Type: Mechanical
Preparation Method: Moist

Soil Description (Visual-Manual)

62.5% base course, 37.5% RAP. Well-graded gravel with sand and asphalt millings, fine to coarse, greyish brown, moist

Sieve Size	% Retained
1 1/2"	1
3/4"	7
3/8"	29
#4	49

Sample No: 62.5% Base, 37.5% RAP Blend as CTB

Lab Sample No: P-1

Date Sampled:

Sampled By: Drill Crew

Date Received:

Sampled From: Lab composite and blend

Depth:

Performed By: RQ/SKG

Date Performed: 1/24/2018

Comments:
Zero air void curves represent specific gravity of 2.6, 2.7, and 2.8 respectively. The bottom blue dotted curve represents -3/4" 62.5:37.5 RAP blend. The middle grey curve represents -3/4" 62.5:37.5 RAP blend with Portland cement. The top, black curve represents oversize corrected density and moisture, and is the compaction target for field construction.

Additional Remarks:

SK GEOTECHNICAL
P. O. Box 80190
Billings, MT 59108-0190
Phone: 406.652.3930
Fax: 406.652.3944

Laboratory Compaction Characteristics of Soil (Proctor)
Project Number: 17-3612G
Makoshika State Park
Glendive, MT

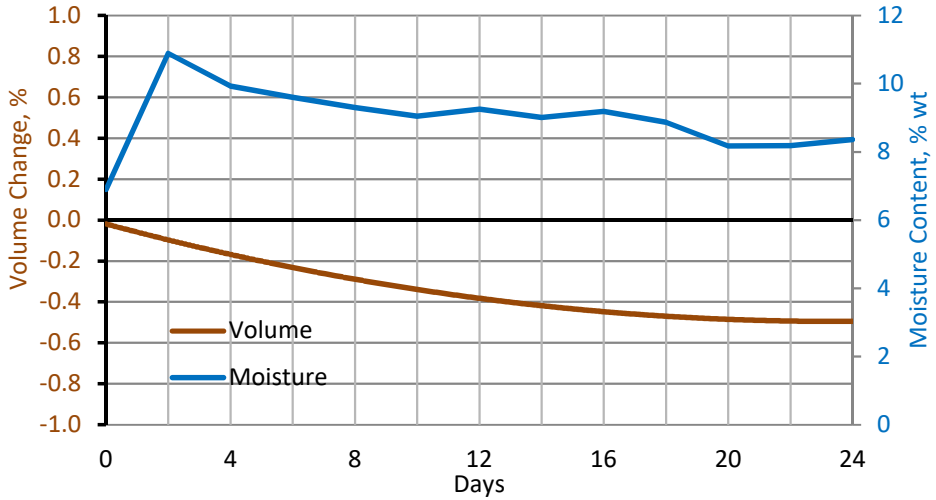
PROCTOR

P-1

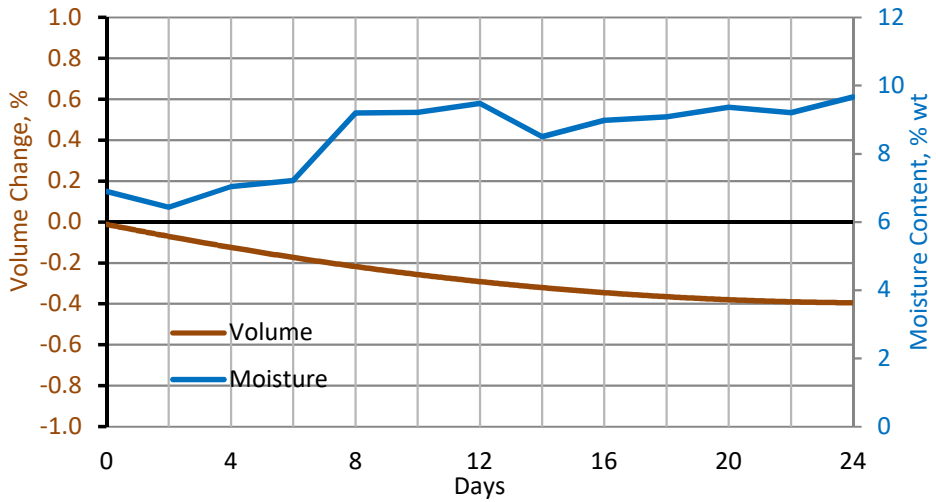
CEMENT TREATED BASE (CTB) MIX DESIGN

PCA Soil-Cement Laboratory Handbook, EB052, 1992,

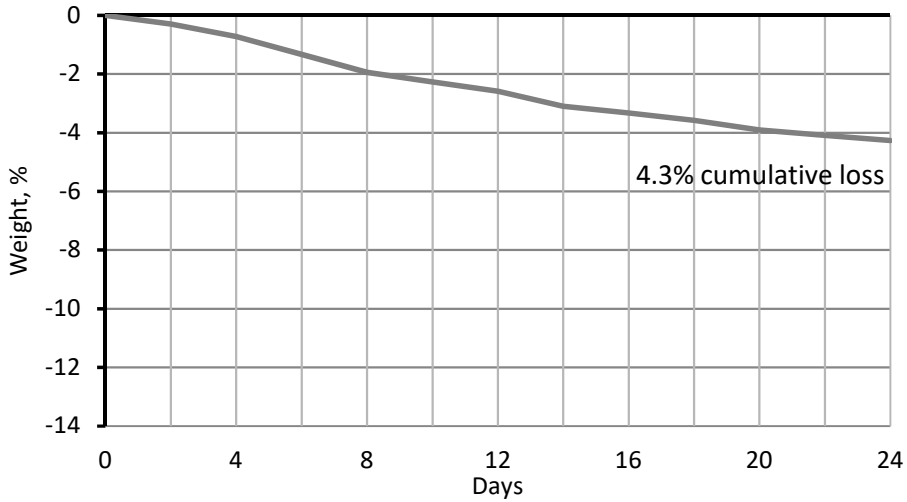
5% Cement AASHTO T 135 Wet/Dry Volume & Moisture



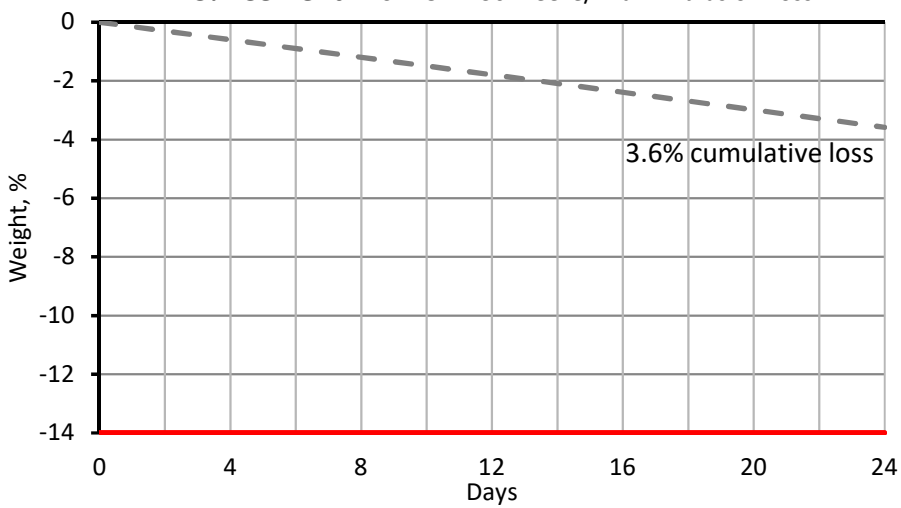
5% Cement AASHTO T 136 Freeze/Thaw Volume & Moisture



5% Cement AASHTO T 135 Wet/Dry Abrasion Loss



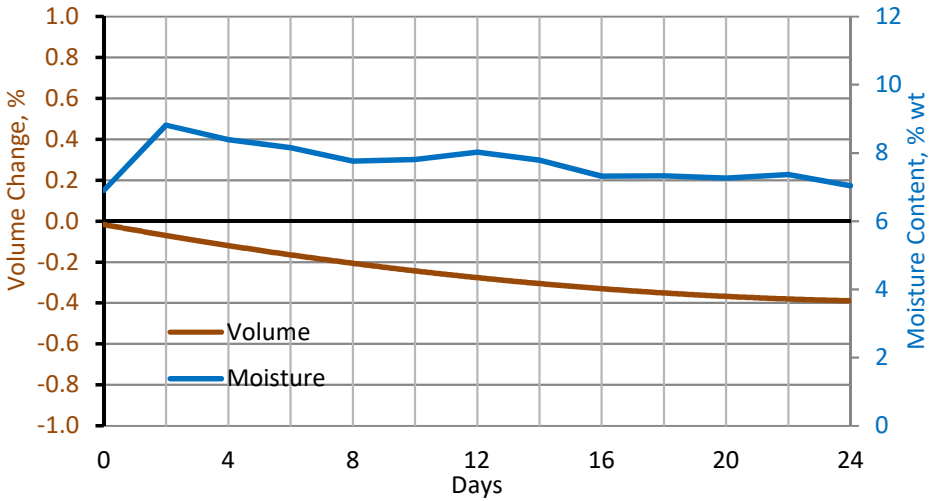
5% Cement AASHTO T 136 Freeze/Thaw Abrasion Loss



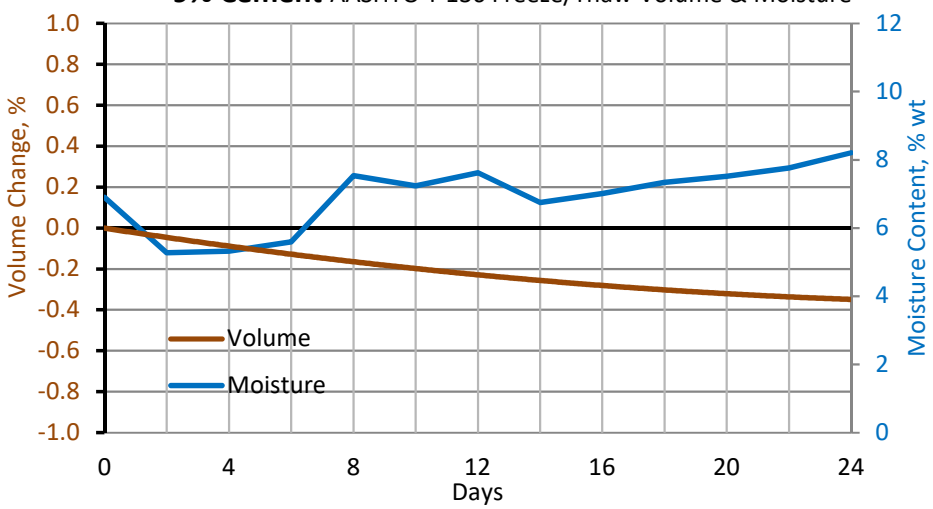
CEMENT TREATED BASE (CTB) MIX DESIGN

PCA Soil-Cement Laboratory Handbook, EB052, 1992,

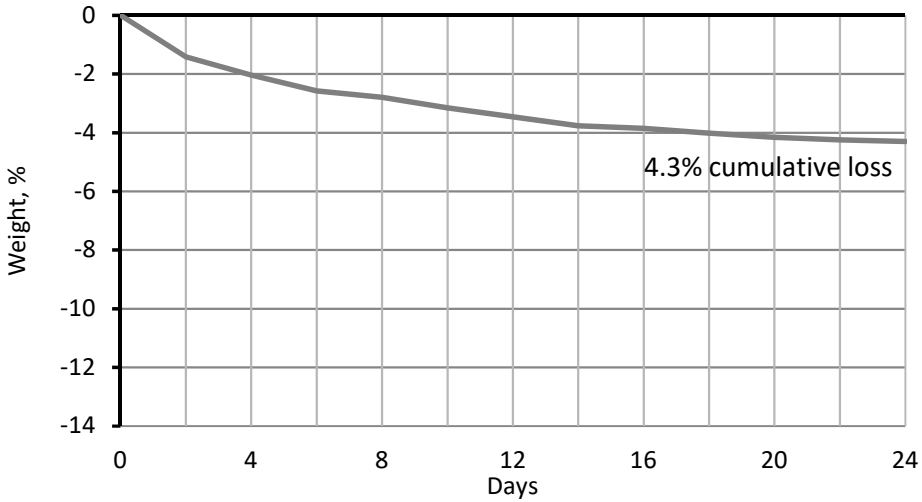
9% Cement AASHTO T 135 Wet/Dry Volume & Moisture



9% Cement AASHTO T 136 Freeze/Thaw Volume & Moisture



9% Cement AASHTO T 135 Wet/Dry Abrasion Loss



9% Cement AASHTO T 136 Freeze/Thaw Abrasion Loss